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THE

EDUCATION AND STATUS OF CIVIL ENGINEERS,

IN THE UNITED KINGDOM AND IN FOREIGN COUNTRIES.

COMPILED FROM DOCUMENTS

SUPPLIED TO THE

Council of the Institution of Civil Engineers,

1868 TO 1870.

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INTRODUCTORY MEMORANDUM.

The Council of the Institution of Civil Engineers, in issuing this volume on the Training and Status of Civil Engineers in the United Kingdom and in Foreign Countries, desire to express, on behalf of the Institution, their cordial thanks for the trouble taken by various correspondents in so fully responding to their inquiry, and for the ready courtesy with which the information so supplied has been in every case communicated.

A few years ago attention was called to the state of technical education in this country, which, it was stated, had been recently shown to be so much inferior to that in other European states as to threaten seriously the industrial interests of Great Britain. The subject was taken up by the Government, and by various public bodies, and much information respecting it was collected and put on record.

The Council of the Institution of Civil Engineers felt it their duty to interest themselves in that part of the inquiry which bore upon their own profession. During the sessions of 1867 and 1868 suggestions had been made to them with a view to their taking steps for promoting and encouraging the theoretical education of engineering students; and after considering the subject maturely, they resolved that it would be highly desirable in the first instance to obtain, from the most direct and authoritative sources, full information as to the system adopted for the education and technical training of Engineers, and generally as to the status of members of the profession, in various foreign countries where this profession had assumed an important position.

With this view the Council issued the following circular:—

THE INSTITUTION OF CIVIL ENGINEERS.
Established 1818. Incorporated by Royal Charter 1828.
25, *Great George Street, Westminster*, S.W.

7 *July*, 1868.

SIR,

The Council of The Institution of Civil Engineers, being anxious to obtain the most complete and reliable information as to Engineering Education (other than Military Engineering) in different countries, have directed me to seek your assistance and co-operation, with a view to the collection of full particulars of the systems of instruction pursued in your country and elsewhere, their cost to the students and to the State, and the effect, or presumed effect, of such preparatory training upon the profession.

The accompanying heads of inquiry have been drawn up to serve as a basis for the investigation, but not in the least degree to limit its scope; and I am to express the earnest hope of the Council, that you will be pleased to promote the object they have in hand to the utmost of your power.

I am, Sir,
Your obedient Servant,
JAMES FORREST,
Secretary.

HEADS OF INQUIRY

As to Systems of Engineering Education in different Countries.

The general system of Engineering Education (exclusive of Military Engineering).

The presence or absence of Government support, and its nature if given.

The courses of study and examinations, if any, required before entering the profession.

A list of the principal establishments for Engineering Education, with programmes of the course of study pursued at each place, and details of the systems of teaching and of the whole *modus operandi* of communicating instruction. Also a Catalogue of the Text Books employed.

The nature of the Diplomas, or Certificates granted, if any.

Whether the plan of serving a regular pupilage to a practising Engineer, as in England, prevails; and, if so, the fees paid by the pupils, and the duration of such pupilage.

The practice of the profession as to the assumption of the style and title of Civil Engineer, without any previous regular training, certificate, or diploma.

The titles of any printed Reports, or other documents, bearing on the subject of Engineering Education, which may be consulted with advantage.

In addition to this, the Council invited suggestions on the subject from any persons who might be willing to aid in the cause.

These appeals were liberally responded to, a very large mass of information having been received, consisting of original reports and statements by Engineers of eminence, and by the authorities of educational establishments, accompanied by voluminous collections of printed documents illustrative of the subject, often in minute detail.

This information has been carefully examined, translated, condensed, abstracted, classified, and arranged, and in some cases, where there was no direct intelligence, reference has been made to published sources of information, in order to render the whole as complete as possible. The result is now given in the following pages, and the matter has been divided into three parts.

The First Part contains information collected as to the educational institutions in Great Britain and Ireland, where instruction is given bearing on the profession of engineering.

The Second Part contains information collected as to engineering education and the status of Civil Engineers in foreign countries.

In Part the Third are published various suggestions which have been offered to the Council, and extracts taken from various publications, bearing on the subject of engineering education generally.

It may be desirable here to give a brief summary of the most important points that appear to be shown by these documents in regard to the status of the members of the profession in different countries, and the nature of the education and training they receive.

It will facilitate any remarks on the latter subject to distinguish clearly between the two kinds of education which it is generally deemed desirable an Engineer should receive.

In the first place, he should be acquainted with such physical sciences as bear on his profession, and should be familiar with the rules and operations necessary to apply their principles in practice. The imparting of this knowledge may be termed the *theoretical education* of the Engineer.

Secondly, he must be acquainted by actual experience with the nature of practical works, and with the operations and processes necessary for their design and construction. The obtaining of this knowledge is his *practical education.*

This twofold training is not peculiar to engineering, it obtains in almost all other professions. In medicine and in law, for example, the theoretical and practical courses of studies are essentially distinct, and the combination of both is necessary to form the competent practitioner.

THE STATUS AND EDUCATION OF ENGINEERS IN THE UNITED KINGDOM (Part I.)

It is hardly necessary to remark, except for the purpose of completing the comparison with foreign countries, that in England the profession of engineering is entirely unconnected with the Government, there being no state corps of Engineers other than those attached to the Army. It is open to any one to enter the profession, and to obtain in it any standing his merits may entitle him to; and all the civil works of the country, whether public or private, are (with some few exceptions, where Royal Engineers have been employed) executed by private practitioners.

There is, further, in England no public provision for engineering education. Every candidate for the profession must get his technical, like his general education, as best he can; and this necessity has led to conditions of education peculiarly and essentially practical, such being the most direct and expeditious mode of getting into the way of practical employment.

The education of an Engineer is, in fact, effected by a process analogous to that followed generally in trades, namely, by a simple course of apprenticeship, usually with a premium, to a practising Engineer; during which the pupil is supposed, by taking part in the ordinary business routine, to become gradually familiar with the practical duties of the profession, so as at last to acquire competency to perform them alone, or, at least, after some further practical experience in a subordinate capacity.

It is not the custom in England to consider *theoretical* knowledge as absolutely essential. It is true that most considerate masters recommend that such knowledge should be acquired, and prefer such pupils as have in some degree attained it, and it is also true that intelligent and earnest-minded pupils often spontaneously devote themselves, both before and during their pupilage, to theoretical studies; but these cases, though happily much more frequent now than formerly, really amount only to voluntary departures from the general rule.

The theoretical knowledge which may, in these cases, be desired, is obtained either by private reading or by attendance at the scientific classes established at various educational institutions, some of which have made special provision for studies of this kind, as may be seen in the particulars given in Part I.

The *practical* education in England is perhaps the most perfect possible, if the opportunities obtained during the pupilage are ample, and the pupil properly avails himself of them; for nothing can give a student so thorough and useful a knowledge of practical works as being actually engaged for a length of time upon them in a really working capacity; in addition to which, the habits of business and the familiarity with all subsidiary arrangements, acquired in this way, have a beneficial influence on the student's future career. This thorough proficiency in practical matters tends largely to compensate for—in many cases to outweigh—the deficiency in theoretical attainments, and it is undoubtedly this, influenced in some degree by the natural self-reliance and practical common sense inherent in the English character, which has given such a high standing to the profession in this country.

The Status and Education of Engineers in Foreign Countries. (Part II.)

In most parts of the Continent the status of Civil Engineers differs materially from that obtaining in England. In almost every country of Europe there exists a state corps of Engineers, educated and supported by the Government, whose business it is to construct and superintend the public works of the nation. Private practitioners are therefore excluded from these works, and have to find employment, as best they can, in private industrial enterprises.

France affords the most perfect example of this system. The Government Corps of Engineers exists under two divisions, viz., the *Ingénieurs des Mines* and the *Ingénieurs des Ponts et Chaussées.* The former have the highest rank, and are employed chiefly, but not exclusively, on mining operations, and works allied thereto; the latter take the more general public constructive works, as their name implies.

There are several classes in each division, Inspectors General, Engineers in Chief, and ordinary Engineers, and promotion is partly by merit and partly by seniority. The total number at present is given (page 43) at 783. They hold a good position in the country; have generally considerable ability; and include in their ranks some men of great eminence in mechanical Science.

Members of either corps are allowed, on special application, to undertake private work on the railways of the country (all other private work being forbidden), and receive a sort of furlough for the purpose. But if their absence from their official duties exceeds five years they forfeit their position, and lose all rights appertaining thereto.

The cases, however, of Government Engineers taking charge of private works are not numerous, as there exists in France a large body of Civil Engineers independent of the Government, and having no official status, who devote themselves to the requirements of private individual enterprises.

These have to make their own way in the profession, and occupy in fact the same kind of position as Engineers in England, except that they have a sort of official guarantee as to their education, as will be hereafter explained.

The education of foreign Engineers is strongly contrasted with that in England in every particular. Practical training by apprenticeship is unknown; the education begins at the other end, namely, by the compulsory acquirement of a high degree of theoretical knowledge, under the direction, and generally at the expense, of the Government of the country. Partly with this, and partly afterwards, there is communicated a certain amount of information on practical matters; but this is imparted in a way differing much from the English plan, and probably with less efficient results.

Thus, while the English Engineer is launched in his profession with the qualification of a considerable practical experience, but with perhaps little or no theoretical knowledge, the foreign one begins with a thorough foundation of principles, but with a limited course of practice; a deficiency, however, which tends to correct itself with time.

The education of both the Government and the private Engineers is on the same system, though carried on in different establishments.

The Government Engineers must have been at first pupils at a large general scientific educational establishment called the École Polytechnique. Admission to this is by public competition, and the standard is very high—so high, in fact, as to exclude all but persons already well advanced. The education in this school is exclusively scientific and theoretical, and from it students are taken to supply not only the corps of Government Civil Engineers, but also all the scientific departments of the army and navy.

After a two years' course in the École Polytechnique, such young men as are candidates for Government employment as Engineers are drafted off, also by strict examinations, into two special schools for the two departments respectively, namely, the École des Mines and the École des Ponts et Chaussées, in each of which the studies last three years.

During the five years thus spent, the *theoretical* education given to the Engineer is very complete, every branch of science bearing on his profession being taught him, and his proficiency being tested by the strictest examination at the end of the term. On passing the final examination, the pupil enters the corps he is destined for, and begins at once his official duty in the lowest grade.

The *practical* education of the pupil, though not so complete or so effective as in England, is by no means neglected. During the three years' study in the special schools, much instruction is communicated having a practical bearing; lectures, descriptions, and exercises being given very fully on practical matters, with the object of making the pupil familiar with the general nature of the works he will hereafter have to do with, and so preparing him for his future experience on them. To aid this, the pupils are sent for a considerable portion of the three years on "missions" to various public works in practical execution under the department they are to be attached to; but whether during these missions they actually take part in the works going on, or merely make observations, and write accounts of what they have seen, is not clear.

At any rate, at the end of the term (being then twenty-three or twenty-four years of age) they are assumed to be capable of doing useful practical work in the lower grade, or third class, and are at once given employment, with pay, as supernumeraries, draughtsmen, or sub-engineers, on some important engineering work in progress, where they gain the further practical experience necessary to fit them for taking more independent positions.

The education both in the École Polytechnique and the subsequent Special School is mainly at the cost of the Government, the pupil only paying small fees. This fact, and the provision for life which the employment affords, produce a very keen competition for the privileges, which keeps up a high standard of qualification.

The education of Civil Engineers practising privately is given in an establishment called the École Centrale des Arts et Manufactures. This was originally founded as a private establishment; but it was afterwards taken to by the State, and is now entirely under Government direction. The instruction, however, is not professedly gratuitous, as the pupils pay moderate fees.

Admission to this school is open to all who can pass a strict entrance examination; but the applications always much exceed the numbers that can be received (about 200 annually), and selection is made of the best.

The course of studies lasts three years, and is generally of the same nature as that given to the Government Engineers, with the exception that mathematical attainments are not pushed quite so high. In the first year the instruction is theoretical only; in the second and third years theoretical and practical instruction are combined. Thus the school aims at representing a combination, on a less extended scale, of the Polytechnic and special schools of the Government corps. It is, moreover, more general and practical in its nature, so as to prepare the pupil as much as possible for any of the varieties of engineering work that may fall in his way, or indeed for other occupations of a scientific nature.

After this course is passed through, a diploma of "Ingénieur des Arts et Manufactures" is given to those students who have passed the highest public examination, and a lower certificate of capacity to those who have simply satisfied the important points. These documents give no claim to any employment, but are considered such good guarantees of ability, that their holders seldom fail to procure paid employment soon after leaving the school. They begin, like the Government Engineers, in subordinate situations, and gain experience and position as they go on.

There is nothing to prevent any Engineer from practising in France who has not been through any of the acknowledged schools, and self-made men of superior practical ability have often succeeded well; but these cases form the exceptions to the general rule.

In Prussia, a corps called Master Constructors (*Baumeister*) are employed by the State, and are educated as follows :—

Each officer must first have received a complete general scientific training in one of the ordinary schools or gymnasia of the country.

He must then be practically engaged for one year with one of the constructive officers of the State.

He is then admitted into a special Government educational establishment in Berlin, called the Royal School of Construction (Königliche Bau Akademie), where he remains two years, the studies comprising all branches of scientific knowledge appertaining to engineering and architecture, particular care being bestowed on construction and drawing. He then passes the first State examination, and enters upon practical paid employment in a subordinate capacity.

After three years of this, he devotes two more years to study, and then passes a second State examination, when he is considered fully qualified for a Government appointment in the higher grade, which he will receive as vacancies occur.

Thus the complete education of the Government official Engineer occupies in all eight years from the time of his leaving the preliminary school, of which four years are devoted to actual practice—a feature that appears to be general in Germany, and that remarkably distinguishes the German curriculum from the French one, and brings it more into analogy with the English; with, however, the very important addition of the theoretical acquirements. It has, in fact, the advantages of the English and the French systems combined.

It is peculiar to the Prussian Government system that the student must fully qualify both in engineering and architecture.

There is also in Berlin a Government school for private practitioners, called the Royal Industrial Academy (Königliche Gewerbe Akademie), analogous to the École Centrale of Paris. This has also the feature of requiring the education to be commenced by passing some time in practical employment. The course in the school occupies three years, and the certificate given is generally a sufficient recommendation to remunerative employment.

In the Duchy of Baden the arrangements for engineering education in the Polytechnic Institution at Carlsruhe are noted for their perfection, and in consequence the school is much frequented by foreigners. Copious information will be found as to this school; and, in order to convey a more complete idea of the nature of the education, there is added a complete list of the questions given for the examination for the Diploma in Civil Engineering in 1867-8. The degree of proficiency, both in theory and practice, required for the proper solution of these questions must be very remarkable.

The system in Austria seems pretty nearly the same as in Prussia, except that there would appear to be only one educational establishment, the Polytechnic Institute, for all classes of Engineers, and that any students are eligible for Government employment, on passing the required examinations. After examination diplomas are granted, guaranteeing the theoretical and practical proficiency of the student; and licenses to practise in engineering, architecture, and surveying must be obtained from the Government, according to prescribed rules. This restriction on private practice appears peculiar to Austria and some neighbouring states. In Prussia, and most other German countries, as in France and England, the right to practise is free.

The system in Russia appears pretty nearly the same as in France.

In Switzerland, the Polytechnic School of Zurich and the Special School of Lausanne bear a high character for engineering education.

In Italy there are also good educational arrangements.

In Spain there is a corps of Government Engineers somewhat analogous to those of France, and their education is properly provided for.

In the United States there is no Government system of education, nor does the English practice of pupilage with a premium prevail. It would appear that young men, after obtaining an education in some college or school, enter at once as paid assistants into Engineers' offices, and afterwards make their way in the profession as best they can.

SUGGESTIONS AND EXTRACTS. (Part III.)

It remains to give a brief notice of the principal points contained in the suggestions and extracts in Part III.

Sir John Rennie's communication refers chiefly to the practical knowledge to be acquired during and after pupilage.

Mr. Conybeare considers that, whereas some years ago the foreign Engineers were deficient in practical experience, and the English in scientific training, at present the former defect has been remedied, but the latter remains, placing the English Engineer at a great disadvantage, as compared with his foreign brethren. He considers that the professional organization in England is defective, and that there is not sufficient security that any one elected to the Institution has really the qualifications of an Engineer.

Mr. Conybeare suggests:—

1. That the Institution might influence for good the scientific education given in the Engineering departments of the colleges and schools.
2. That no Engineer should take a pupil without adequate scientific training.
3. That Engineers in different departments of the profession should exchange pupils for a time.

Mr. Heppel insists on more theoretical knowledge being acquired before and during pupilage, and suggests that a Faculty of Engineers might be created at one or more of the public universities, not for educational purposes, but for examination, and the conferring of a degree—say, "Master in Engineering"—on competent candidates.

Mr. Callcott Reilly, admitting the deficiency in theoretical acquirements of so many young men practically studying the profession, suggests that the influence and resources of the Institution might be beneficially employed by the establishment of "Readerships," with the object of giving such students instruction in theoretical knowledge, or rather for aiding them in instructing themselves.

The Society of Arts Committee approve of the system of pupilage, but recommend an extension and improvement of the preliminary scientific education given in ordinary colleges, so that students should enter on their pupilage as well instructed as foreign students enter the special schools of the Continent. The proficiency of students in the college should be tested by examinations, and diplomas conferred, not, however, as certifying competency to practise, but merely vouching that they have attained such proficiency in the theoretical studies as to be fit to enter on a practical pupilage with advantage to themselves and their employers. The examination should be conducted with the aid of two independent examiners, one appointed by the Government, and one by the leading Institution of the profession.

After pupilage, a voluntary public examination might be held, partly practical and partly theoretical, with the view of testing whether the young men have really profited by the pupilage; and diplomas should be granted to young men of undoubted merit.

They recommend that persons taking pupils should give the preference, as far as possible, to those adducing evidence of the possession of adequate scientific instruction.

Professor Fleeming Jenkin points out forcibly and lucidly the defects of the present English system, and the great superiority of the foreign one as regards theoretical knowledge. His views as to improvement will be found concisely stated on page 204.

Mr. Scott Russell laments the evils threatened to this country by the deficiency of technical education generally, and recommends large measures for averting them.

Professor Leone Levi recommends the establishment of an industrial university, or a superior technical institute, for the direction and promotion of technical, industrial, and professional instruction in the United Kingdom.

PART I.

EDUCATIONAL INSTITUTIONS IN GREAT BRITAIN AND IRELAND

WHERE INSTRUCTION IS GIVEN BEARING ON THE PROFESSION OF ENGINEERING.

EDUCATIONAL INSTITUTIONS *in* GREAT BRITAIN *and* IRELAND *where* INSTRUCTION *is given bearing on the* PROFESSION *of* ENGINEERING.

THE information contained in this part has either been communicated directly to the Council, or taken from documents published by the various establishments named.

These establishments are:—

- King's College, London.
- University College, London.
- The Royal School of Mines, London.
- The Royal School of Naval Architecture, London.
- The University of Edinburgh.
- The University of Glasgow.
- Trinity College, Dublin.
- The Royal College of Science, Dublin.
- Queen's College, Cork.
- Owens College, Manchester.

Some notes are added, incidentally, on—

- The Royal Agricultural College, Cirencester.
- The Whitworth Scholarships.
- The Examinations for the Engineering Service for India.

KING'S COLLEGE, LONDON.

This is one of the most frequented institutions for the preparatory training of young men about to enter the profession of Civil Engineering in England.

It comprises several departments of education, but the one which has more particularly to do with this subject is the "Department of Applied Sciences," which is thus defined by the authorities of the College:

> "The object in view in this department is to provide a system of general education, practical in its nature, for a large class of young men who in after life are likely to be engaged in commercial and agricultural pursuits, or in professional employments, such as Civil and Military Engineering, Surveying, Architecture, and the higher branches of manufacturing art."
>
> It is also intended to prepare students for scientific examinations, such as those of the University of London, the Department of Public Works, India, Whitworth Scholarships, &c.
>
> The whole course occupies three years, and forms an appropriate introduction to that kind of instruction which can only be obtained within the walls of the manufactory, or by actually taking part in the labours of the surveyor, the engineer, or the architect.

The following subjects are taught in this department:

1. Mathematics.

2. Natural Philosophy in its various branches, including Practical and Experimental Physics.

   These are taught by lectures and illustrations in the usual way.

3. The Arts of Construction in connection with Civil Engineering and Architecture.

   This consists of lectures on Materials, Foundations, the principles and practice of the design and construction of Railways, Bridges, Houses, Sewerage, Tunnels, Canals, Docks, Harbours, Lighthouses, &c.; and the more advanced students are exercised upon essays on various engineering questions, and on constructive designs for works

4. Manufacturing Art and Machinery.

   This comprises lectures on the manufacture of iron and steel, and other metals, and on machinery and manufacturing processes of various kinds; the lectures "being intended to add a knowledge of practice to a knowledge of theory taught by the other professors."

   The students have the opportunity of visiting works in the vicinity of London; and, at an advanced stage, are exercised on essays and designs as in the last-mentioned subject.

The instruction in this branch is aided by the establishment of an Engineering Workshop, in which the students are allowed to work, and where they have the opportunity of learning some of the simplest processes of practical working in wood and metals.

5. Land Surveying and Levelling.

   These are taught theoretically by College lectures, and practically by exercise in the field.

6. Drawing.

This comprises not only free drawing, but geometrical projection, and practical drawing of the kind used by architects and civil and mechanical engineers.

It is taught by actual practice in the ordinary way.

7. Chemistry.

Taught by lectures and laboratory practice.

8. Geology and Mineralogy.

Taught by lectures and by occasional field excursions.

9. Photography.

Lectures and demonstrations.

Examinations are held, and prizes and certificates are given; and a few of the students exhibiting most proficiency are elected "Associates," who are entitled to perpetual free admission, and to special honour in the College.

UNIVERSITY COLLEGE, LONDON.

This establishment is also designed to afford preparatory training to students of Engineering. It contains a *Department of Civil and Mechanical Engineering*, of which a special prospectus is issued annually.

The following extract from the prospectus will explain the general objects aimed at:

> The course of instruction in this department is not intended to supersede the necessity of the Engineering student serving a pupilage on the works of a Civil and Mechanical Engineer, as it is only upon them that he can obtain a thorough knowledge of the practical details of construction; but it is designed to teach him the theoretical principles of his profession, together with those habits of thought and observation without which he will not be able to take full advantage of the practice that will come before him during his term of pupilage.
>
> The complete course extends over three sessions, and embraces the following subjects:
>
> Mathematics, pure and applied.
> Applied mechanics.
> Physics.
> Physical laboratory.
> Chemistry.
> Chemical laboratory.
> Civil and mechanical Engineering.
> Mechanical drawing and designing.
> Surveying and levelling.
> Geology.
>
> Students who have gone through the complete course, and who have passed the examination at the end of each of the three sessions, to the satisfaction of the Professors, will be entitled to the General Certificate of Engineering.

There is also a Professorship of Architecture and Construction, in which these subjects are comprehensively treated in two courses, viz.:

Architecture as a Fine Art.
Architecture as a Science.

ROYAL SCHOOL OF MINES, LONDON.

The object of this School is set forth in the following extract from the Prospectus:

> "The principal object of the Institution is to discipline the students thoroughly in the principles of those sciences upon which the operations of the miner and metallurgist depend. Of course, nothing but experience in the mine and in the laboratory can confer the skill and tact requisite for the practical conduct of those operations; but, on the other hand, it is only by an acquaintance with scientific principles that the beginner can profit by that experience, and improve upon the processes of his predecessors."

The course of study occupies three years, and comprises the following subjects:

Physics and Applied Mechanics.
Chemistry (Inorganic).
Laboratory Practice.
Mechanical Drawing.
Geology.
Palæontology.
Mineralogy.
Metallurgy and Assaying.
Mining.

The mode of instruction is by systematic courses of lectures, by written and oral examinations, by practical teaching in the laboratories and drawing office, and also, under certain conditions, by field excursions.

Scholars who have gone through the proper course, and pass the requisite examinations, are entitled to receive an official certificate, conferring on them the title of *Associate of the Royal School of Mines.*

ROYAL SCHOOL OF NAVAL ARCHITECTURE AND MARINE ENGINEERING, SOUTH KENSINGTON.

This is a School for the instruction, primarily of Admiralty pupils from the Royal Dockyards, and of Officers of the Royal Navy; and secondarily of naval architects and ship-builders in wood and iron, marine engineers, foremen of works, shipwrights, and other persons desirous of studying Naval Architecture.

The course of instruction is calculated to last for four years, on the supposition that the student comes with a fair knowledge of Drawing and Practical Geometry, and an elementary knowledge of Mathematics and Physics.

Diplomas are given to all persons, whether they have received their instruction at the School or not, who pass the final examinations of the School, provided that they give satisfactory evidence of having gone through a certain course of practical work. These diplomas are of two grades, according to the success of the candidate in the examination; the title of the higher grade being Fellow, and of the lower, Associate, of the Royal School of Naval Architecture.

The subjects for the lower grade are:

Arithmetic, Algebra, Mensuration, Euclid, Trigonometry, Logarithms, Elementary Mechanics, and Hydrostatics.
Elementary Physics.
Practical Ship-building.
Practical Engineering.
Steam.
Ship and Engine Drawing.

For the higher grade, further proficiency is required in Mathematics, in the Designing of ships and engines, and in some other branches of science.

UNIVERSITY OF EDINBURGH.

The arrangements for Engineering instruction at this establishment are thus described by the able Professor of Civil Engineering, Mr. Fleeming Jenkin, F.R.S.:

"The instruction provided for Engineers at the University of Edinburgh is now, I think, fairly well organized. It consists of at least a two-years' course of study, arranged as follows:

First year.

Mathematics.
Natural philosophy.
Engineering.
Mechanical drawing.

Second year.

Summer Session.—Surveying, levelling, and setting out.
Winter Session.—Mathematics.
Chemistry.
Engineering.
Mechanical drawing.

These two years of study are followed each by a general University examination, leading to a degree of Bachelor, or Licentiate of Engineering. This degree has not yet been conferred, owing to certain legal difficulties, which are in process of removal.

The course called Engineering consists of about 100 lectures in each session, and treats of the following subjects:

Year A.

1. Principles of statics; couples; parallel and inclined forces; centre of gravity; moments of inertia.
2. Equilibrium and stability of frames, bracing-cords, ribs and linear arches.
3. Strength of materials.
4. Strength of the simpler forms in which materials are used.
5. Application of mechanical principles to combined structures, especially roofs and bridges.
6. The construction of roads, railways, and tramways.
7. Principles of dynamics; Newton's laws of motion; conservation and transformation of energy.
8. Application of the principles of dynamics to prime movers, especially to locomotives.
9. Applications of machinery to manufactures.

Year B.

1. Application of statics to the determination of frictional stability and to hydrostatics.
2. Hydrodynamics.
3. The construction of waterworks.
4. Drainage of towns.
5. Construction of harbours.
6. Application of kinematics to machinery, illustrated by millwright work.
7. The construction of the condensing steam-engine.
8. The construction of water-wheels, turbines, and primary machinery.
9. Some special applications of machinery to manufacturing purposes.

"The student can begin his course of study either in year A or in year B.

"The Lectures on Chemistry, on Natural Philosophy, and on Mathematics, each form courses of about a hundred days of attendance, and are probably as good as can be obtained anywhere. The mechanical drawing class is as close an approach to the actual drawing office as can be provided. It is open every day during the session, from 10 to 2 P.M.

"The class of surveying, levelling, and setting out is a practical class, instruction being given in the field.

"All these classes are in practical operation. The number of students attending the Engineering Class is about 25 annually; they work hard, and profit by the lectures.

"A workshop will next year be affiliated to the University, but I do not attach great importance to it as a means of education.

"Chairs of geology and of architecture are alone, in my opinion, required in Edinburgh to render the education offered to the Engineering student very complete."

GLASGOW UNIVERSITY.

In this University the Faculty of Arts, which contains Mathematics and Natural Philosophy, includes also a Professorship of Civil Engineering, the studies in which are summed up briefly as follows:

> The stability of structures, the strength of materials, the principles of the action of machines, prime movers, whether driven by animal strength, water, wind, or the mechanical action of heat (as in the steam-engine), the principles of hydraulics, the mathematical principles of surveying and levelling, the engineering of earthwork, masonry, carpentry, structures in iron, roads, railways, bridges and viaducts, tunnels, canals, works of drainage and water supply, river works, harbour works and sea-coast works.

A certificate of "Proficiency in Engineering Science" is granted to students who have passed two sessions in the above studies, and also satisfy the examiners as to their knowledge of mathematics, natural philosophy, chemistry, geology, and mineralogy.

The following notes on the subject are by the present able Professor of Civil Engineering at this University:

NOTES AS TO INSTRUCTION IN ENGINEERING SCIENCE, DRAWN UP FOR THE INFORMATION OF STUDENTS.

1. *Preliminary Education.*

Of the ordinary branches of elementary education *arithmetic* is of special importance to the student of Engineering; and he ought to be familiar in particular with the most rapid ways of performing calculations consistently with accuracy.

It is desirable that he should be well instructed in engineering and mechanical drawing, as part of his preliminary education; but he may, if necessary, obtain that instruction during the intervals of an University course.

It is also desirable, *if possible*, that the elementary parts of mathematics, such as plane geometry, plane trigonometry, and algebra as far as quadratic equations, should form part of his preliminary education, as thereby time and labour will be saved during his University course.

2. *University Course.*

The course of study and examination adopted by the University of Glasgow is described in the Glasgow University Calendar.

In drawing up that course the University have had in view to avoid altogether any competition with the offices of civil engineers, or the workshops of mechanical engineers, or any interference with the usual practice of pupilage or apprenticeship; and they have accordingly adopted a system which is capable of working in harmony with that of pupilage or apprenticeship, by supplying the student with that scientific knowledge which he cannot well acquire in an office or workshop, and avoiding any pretension to give him that skill in the conduct of actual business which is to be gained by practice alone.

The University course may be gone through either before, during, or after the term of pupilage or apprenticeship, according to convenience. An arrangement which is sometimes found to answer well is to devote the winter to academic study and the summer to the practice of engineering. A student who is not a candidate for a certificate in engineering science may attend as few or as many classes as he thinks fit.

(Signed) W. J. MACQUORN RANKINE.

Glasgow University, 1865.

TRINITY COLLEGE, DUBLIN.

In addition to the ordinary course of academical instruction, in which the sciences appear to be well represented, there are in this

College four special technical or "Professional" Schools, viz., for Divinity, Law, Medicine and Surgery, and Engineering.

The latter was founded in 1842 "with the view of combining the theoretical and practical instruction requisite for the profession of Civil Engineering, and of imparting to the members of that profession the other advantages of academical education."

The peculiarity of this arrangement, as compared with those of the English and Scotch Colleges, is that the Dublin College professes to furnish *all* the information, practical as well as theoretical, necessary to prepare a student for his profession, so that when he leaves the College he is supposed to be at once competent, without pupilage, to undertake professional practice.

The professional course continues for three years. The instruction, which is given partly by lectures and partly in the laboratory and the field, is arranged as follows:

First year (Junior Class).

Mathematics.
Theoretical Mechanics.
Chemistry and Mineralogy applied to the Arts of Construction.

Second year (Middle Class).

Practical Mechanics.
Principles of Physics.
Drawing, Surveying, and Levelling.

Third year (Senior Class).

Geology.
Practical Engineering.
Drawing, Surveying, and Levelling.
Field Work in general.

Students passing the final examination are entitled to receive the degree of *Licentiate in Engineering*, and after three years' public practice of the profession they may be raised to the rank of Master in Engineering. The business of the School of Engineering is conducted by five lecturers: one in mathematics, two in mechanics, together with a professor of Chemistry and Geology applied to the arts of construction, and a professor of the Practice of Engineering.

ROYAL COLLEGE OF SCIENCE FOR IRELAND, DUBLIN.

This establishment is under the Science and Art Department of Government. It is said, in the prospectus, to supply—

As far as practicable, a complete course of instruction in sciences applicable to the industrial arts, especially those which may be classed broadly under the heads of mining, agriculture, Engineering, and manufactures.

The course comprises three years' study. In the first two years the instruction is general: in the last year it is specialized under the heads of (A), Mining; (B), Agriculture; (C), Engineering; and (D), Manufactures.

Division C, Engineering, comprehends—

Mechanism and Machinery.
Mechanical Drawing.
Engineering and Surveying.
Geology and Palæontology.

Division D, Manufactures, comprises—

Applied Mechanics and Physics.
Applied Chemistry and Technical Analysis.

There are six Royal Scholarships, and nine Royal Exhibitions attached to the College.

A diploma of Associateship of the College is given to students who pass in certain specified subjects.

QUEEN'S COLLEGE, CORK.

In addition to the usual scientific instruction this College has also a Professorship of Civil Engineering, under which a three years' course is given, the particulars and objects being thus stated by the present professor:

Queen's College, Cork, Aug. 4, 1868.

DEAR SIR,

Persons desirous of entering the College as students in Civil Engineering are required to pass an entrance examination. They are then obliged to attend, during three sessions, certain courses of lectures and pass examinations in the subjects of them at the end of each session.

At the end of the course the successful students receive a certificate from the College, signed by the different professors whose lectures they have attended, certifying that they have attended the required lectures and passed the examinations.

If the students desire to obtain the University "*Diploma in Civil Engineering*" they must, in addition to the above, pass a University examination at the end of their second long vacation, and another, viz., the Diploma examination, at the end of the third. The course originally extended over only two years, but after some experience it was extended to its present length of three years.

The above course is designed to occupy the whole of the student's time during the three years in which he attends the College, and is intended to be completed before the student enters an office, in this differing from the system pursued at Glasgow, the London Colleges, &c. Without entering on the general question of the relative advantages of a systematic course of instruction in a college previous to apprenticeship, and of a combination of the two simultaneously, I may point out that the small number of engineers' offices in the neighbourhood of the College obliged the authorities to adopt the system now established. A considerable proportion of the number of the students entering the engineering department of the College never succeed in completing the course; and finding themselves not adapted to the engineering profession, turn their attention to other pursuits; and you will see accordingly that the strictly professional element is not introduced into the first year, and only slightly into the second, as a considerable portion of the course on surveying and mensuration is of use to others than engineers, and hence a student failing to get beyond his second year has still gone through a course of instruction from which he may derive much benefit.

With regard to the courses with which I am directly connected, I may observe that I believe that the students derive much benefit from being made to go through a systematic course of instruction in the principles of geometrical drawing, and their application to the delineation of bodies of simple form, before undertaking the drawings of complicated structures.

In the course of surveying the students are expected to make themselves thoroughly familiar with the adjustment and use of all the instruments usually employed by the Civil Engineer, and which are provided in the College, and a certain amount of surveying work is done by the class under the direction of the professor, the work being so laid out as to afford examples, as far as possible, of the different kinds of work the student will meet in practice, and as illustrative of what has been taught at lecture; but it is not expected that at this period of his course the young engineer could afford sufficient time to become an expert surveyor.

In the course on Civil Engineering the student's attention is chiefly directed to those subjects which he might not have time or opportunity to make himself acquainted with in an office. For instance, the nature and properties of the materials used by the engineer, the sources from which they are obtained, and the methods of obtaining them; the whole subject of the "strength of materials" and the discussion of the methods of estimating the strains in some of the ordinary structures; hydraulics; the principles of some of the machines used by the civil engineer: the remainder of the course being given to an outline of the design of the principal engineering works.

(Signed) Alex. Jack,
Prof. of Civil Engineering,
Queen's College, Cork.

OWENS COLLEGE, MANCHESTER.

A department of Civil and Mechanical Engineering has lately been added to this College.

The following extract from the prospectus will explain the course of education pursued:

The complete course of instruction in this department, extending over three years, embraces the following subjects:

First Year.

Mathematics.
Natural philosophy (mechanics).
Chemistry.
Geology.
Geometrical and mechanical drawing.

Second Year.

Mathematics.
Natural philosophy (physics).
Chemistry.
Mechanical Engineering.
Civil Engineering.
Drawing and surveying.

Third Year.

Mathematics.
Natural philosophy (mathematical).
Mineralogy.
Engineering (Senior Class).
Drawing and surveying.

Successful attendance on the course will furnish a thorough scientific groundwork for the attainment of the knowledge requisite for the prosecution of the higher branches of the Engineering profession, but it is not intended to supersede the practical training which can only be obtained in the office of a Civil, or the workshop of a Mechanical, Engineer.

Certificates in Engineering will be granted by the College. The examination for these certificates will comprise all the subjects recited above.

THE ROYAL AGRICULTURAL COLLEGE, CIRENCESTER.

This is only connected with the present subject, inasmuch as the constructive operations of agriculture may be supposed (as is usually the case abroad) to belong to the province of the Engineer.

The College has courses of chemistry, geology, elementary mathematics and mechanics, mensuration, surveying, &c.; but constructive operations, draining, and mechanical appliances appear to be only incidentally treated of.

WHITWORTH SCHOLARSHIPS.

In 1868 Mr. (now Sir) Joseph Whitworth founded thirty Scholarships, each of £100 per annum, tenable for two or three years—

> To be applied for the further instruction of young men, natives of the United Kingdom, selected by open competition for their intelligence and proficiency in the theory and practice of mechanics and the cognate sciences, with a view to the promotion of Engineering and Mechanical industry in this country.

The competition for these embraces several theoretical subjects, viz.:

Mathematics.
Mechanics.
Practical geometry.
Drawing.
Physics.
Chemistry;

and also awards an equal number of marks for proficiency in the handicrafts of

Smith's work.
Turning.
Filing and fitting.
Pattern making and moulding.

A certain amount of knowledge in both theory and practice is indispensable; the object being, while requiring a practical acquaintance with a few simple tools as a *sine quâ non,* to render the competition accessible on fairly equal terms to the student who combines some practice with his theory, and the artizan who combines some theoretical knowledge with perfection of workmanship.

The management of the arrangements for these Scholarships is vested in the Government Council on Education.

ENGINEERING ESTABLISHMENT OF THE DEPARTMENT OF PUBLIC WORKS OF INDIA.

This is not an educational establishment; it is merely included in the present list on account of the periodical competitive examinations conducted in it for junior assistants, of which the following particulars may be useful.

Candidates must be not exceeding twenty-four years of age, and must have already passed three years either entirely with a practising Engineer, or partly thus and partly in studying Engineering in a school or college recognized for the purpose.

The subjects of examination include Arithmetic, Mensuration, Trigonometry, Algebra, Euclid, Statics, Dynamics, Hydrostatics, and Hydraulics, and also Engineering subjects, as follows:—

Engineering.

Projects for bridges, locks, dams, harbour works, roads, tramways, and other Engineering works.

Irrigation, drainage, water supply, sewerage and mining.

Making working drawings of machinery, and plans, elevations, and sections of buildings.

Carpentry, ironwork, and properties of materials in general.

Free-hand drawing.

Map drawing.

Framing of estimates and specifications from given plans and data.

Surveying.

Trigonometrical surveying and traversing with the theodolite.

Land surveying with compass and chain, and plotting from a field-book.

Levelling, and use of the instruments employed.

Geometrical drawing.

PART II.

ENGINEERING EDUCATION,

AND

THE STATUS OF CIVIL ENGINEERS,

IN FOREIGN COUNTRIES.

ENGINEERING EDUCATION, *and the* STATUS *of* CIVIL ENGINEERS, *in* FOREIGN COUNTRIES.

THE circular issued by the Council has elicited a large amount of information on these points. Many communications have been sent in reply, prepared in most cases by persons of considerable eminence, and accompanied by documents giving full particulars as to the instruction given in the Schools.

In the following pages all such communications as, owing to the eminence of the writers, or the nature of the information conveyed, are of special value, are printed entire, those sent in foreign languages having been translated for the purpose.

In many cases, however, it has appeared that an abstract of them would be sufficient.

In addition to the information obtained directly by the Council, many valuable particulars, remarks, and opinions, have been found in published works, particularly in the Reports of the French Commission;[1] in that of M. Koristka to the authorities of Prague;[2] and in the Replies to Lord Stanley's Circular on Education addressed to our Ministers abroad.[3]

Some extracts and translations have been made from these documents, and are inserted in their proper places; and other references are made to the works themselves, which, it may be observed, contain a large amount of detailed information as to the educational establishments of the Continent generally, and may be referred to with advantage by those who wish to study the subject further.

Before giving the information as to the various countries separately, it is desirable to insert the following.

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[1] See page 70.

[2] Der höhere polytechnische Unterricht, in Deutschland, in der Schweiz, in Frankreich, Belgie, und England. Ein Bericht an den h. Landesanschluss des Königreich Böhmen. Von Carl Koristka, Professor am polytechnischen Landesinstitut zu Prag. Gotha, Besser, 1863.

[3] Technical and primary education. Circular of Lord Stanley to H. M. Representatives abroad, together with their replies. Presented to Parliament, 1868. London, Harrison and Sons, 1868. 8vo.

See also, Copies of Answers from Chambers of Commerce to Queries of the Vice-President of the Council as to Technical Education. Parliamentary Papers, 25th March, 1868.

GENERAL OBSERVATIONS ON THE POLYTECHNIC SCHOOLS OF THE CONTINENT.

The French Commission remark on these as follows:

POLYTECHNIC INSTITUTES.

The various institutions intended for commercial or industrial education present, under identical designations, very great diversities in Germany, but the case is different with polytechnic establishments, which, under the name of *Gewerbs-Institut* at Berlin, and of Polytechnic School or Institute in Saxony, Bavaria, Austria, Würtemberg, Switzerland, and the Grand Duchy of Baden, are intended to train Civil Engineers for the services of bridges, roads, mines, and manufactures, mechanical engineers, manufacturing chemists, architects, forest engineers, &c. In all these establishments scientific instruction is given in a very high degree, and sometimes even to an extent superior to the requirements and the end to be attained; but, everywhere also, the technical branch of this instruction is cultivated with the utmost care. The polytechnic institutes are at once schools of theory and of application, and present, in this respect, a very great analogy with the Central School of France.

In all these establishments the pupils enter at seventeen or eighteen years of age, and must possess a preparatory education corresponding to the special studies they intend to follow. The choice of his branches of study having been] made by the pupil, the courses he must attend are indicated to him and become almost everywhere compulsory. However, this obligation is not always absolute, and the liberty accorded to the pupils, of not attending certain scientific courses, has the effect of inducing the professors to confine their theoretical instruction within the limits of what is really useful to those divisions.

The part of the first courses which forms the scientific foundation of the technical applications is usually common to several of the special divisions into which the pupils are separated, and each division likewise receives the peculiar instruction required for it. These divisions, more or less numerous according to the country, are in general the following:

Engineers for bridges and roads.
Civil Engineers for railways, &c.
Architects and builders.
Mechanics.
Manufacturing chemists.
Mining Engineers.
Forest Engineers.

All the institutes do not comprise the same number of divisions, but the first four or five are almost universally adopted, if there be no special establishment to replace them.

The peculiar arrangement and gradation of the studies nearly always possess a remarkable feature, which is that the first part of the studies of each special division, which requires one or two years, is so regulated that it constitutes a body of knowledge sufficiently complete to allow a young man to break off there and enter advantageously on the second-rate positions in the career he has chosen. After accomplishing this first part of the studies, a pupil may become an able assistant engineer of roads and bridges, or of civil architecture (*Werkmeister*), a builder (*Baumeister*), overlooker or head mechanician, a dispensing chemist, or foreman of chemical works, a head miner, a mining overseer, a forest agent, &c. In more than one state, pupils are even required, after reaching this first stage of technical instruction, to pass a year or two in building yards, workshops, or factories, before going through the rest of their studies. This practice, which presents the inconvenience of interrupting the studies and exposing many pupils to the danger of forgetting a part of them, has, on the other hand, the advantage of maturing their minds by practice, of showing them the applications of science, and of not leading to higher studies any but those who really have a vocation for them. It is, however, practicable only under the system of out-door pupils, which is universal in Germany, and for pursuits in which there is no limit of age.

Observations on the Extent to which the Theoretical Studies are carried.

We have stated above that the mathematical studies in these institutes are of a high order. It is, however, right to remark that those which correspond to the first period we have just indicated, are nearly everywhere more elementary, and consequently accessible to pupils who only aspire to second-rate positions in each special or technical branch. But the case is very different for the last years of study, and, though we entertain the utmost respect for the learning and zeal of the professors, we feel bound to state that generally, in these establishments, a greater range than necessary is given to the use of pure mathematics. The programmes too often contain lessons devoted to the doctrine of probabilities and to the calculus of variations, which the pupils will certainly never have to use, and which absorb valuable time. The use of the differential and the integral calculus is also carried too far. In fact, though it may be good and useful that an Engineer should be familiar with the theory of the methods of the calculus, it is not equally necessary to pursue the study to such an extent in order to teach the applied sciences, which can be explained quite as accurately by elementary methods more easy to understand. It is more than probable that this extreme attention to refined mathematical theory prevents a good many pupils from completing, as they might have desired, the full course of technical studies. It would doubtless be more judicious to reserve for a special division, which is not compulsory, and is devoted exclusively to scientific studies, all these higher subjects, which would then be addressed to young men preparing to become teachers. At the Zurich Polytechnic School, there is a division of this kind, to which are admitted, either as students or free auditors, all who desire to follow the scientific courses properly so called, and in this division lectures are also given on almost every branch of human knowledge.

Notwithstanding these reflections, which are especially dictated by the interest and esteem inspired by these establishments, it is only fair to acknowledge that this high order of instruction, carried on at the great number of polytechnic institutes founded in Germany within the last thirty years, has powerfully contributed to the development of a taste for profound scientific studies, and for the applications of science to all branches of the public service and to industry. We had been made aware of this progress some years before, by the remarkable publications which appeared beyond the Rhine on all these questions, and what we have seen has only confirmed the inferences we had drawn from an examination of the works mentioned. In this respect, Germany appears to us to have made, as regards the diffusion of the sciences, and particularly their application to the requirements of public works, arts, and industry, far more rapid progress than England; and it is important that France should seriously consider this matter, for the day is, perhaps, not far distant when Germany, joining to the low price of labour and to the frugal habits of its inhabitants all the resources of science, will become for our industry a rival as formidable as the one which, on the other shore of the channel, has hitherto most occupied our attention.

Study of applied Science.

In all the polytechnic institutes that we visited, the applications of the sciences are taught to the pupils not only by lessons, but by detailed and progressive studies which they are obliged to make of all the parts of the art or of the services for which they are destined. The Engineers, architects, and mechanicians study and reproduce by drawings and plans all the details of construction, from the most elementary to the most difficult and most complicated. All the parts of the plans must be calculated according to the rules of science and art.

The pupils, it is true, make very free use of works such as the handbooks published by eminent professors, as M. Weisbach and M. Redtenbach, but they must nevertheless have understood the principles on which the rules given by those learned authors are based.

Chemical Laboratories and Collections.

The chemical classes have at their disposal extensive and well-organized laboratories, in which the pupils are allowed, on payment of a very moderate fee, to perform manipulations, and thus join practice to theory. Numerous collections of instruments, models, minerals, and technology, and also libraries supplied with all the new publications, complete the means of instruction.

General Arrangements.

Everywhere the halls are large, well-lighted, and space is not spared. Most of these institutes are of recent foundation, and the buildings have quite a monumental character. The rivalry of the different States has had something to do with this progress; it has led each of them to found at least one of this kind of establishments, and to make considerable sacrifices to ensure its success. Such a friendly rivalry we would fain see arise between our great manufacturing centres, as it would in a short time, without being very burdensome to the State, endow the country with the instruction so much needed to enable our industry to hold its own in the increasingly arduous struggle with foreigners.

Distribution of the Polytechnic Institutes.

These establishments, which resemble the Polytechnic School and Central School of France, are distributed through the different States of Germany as follows:

Names of States.	Number of Institutes.	Number of Inhabitants to each Institute.	
		Per State.	Mean.
Austria	5	7,400,000	5,500,000
Prussia	1	17,000,000	
Bavaria	1	4,615,648	
Würtemberg	1	1,783,967	
Saxony	1	2,235,240	
Baden	1	1,359,291	

The great inequalities between the numbers of inhabitants to one polytechnic institute need occasion no surprise, since, apart from all consideration of population, each State has seen the propriety of itself providing for the intellectual wants of its population. The number of inhabitants which, for all Germany, corresponds to an institute of this kind is 5,500,000, whilst in France we have only two analogous institutions for 37,382,225 inhabitants, or one for 18,691,600 inhabitants. Evidently the whole of the German States have made, for the diffusion of the physical and mathematical sciences, as well as for their application to the public services and to industry, very considerable sacrifices, which cannot fail to produce great effects on the progress both of science and of industry.

General Influence on the Progress of Science.

Though we have felt bound to criticize the high reading of certain branches of mathematics, it is none the less true that the great number of chairs open to distinguished men of science, and the emulation engendered by the rivalry of these establishments, which dispute the honour of possessing the most illustrious professors, must direct many superior minds to scientific studies. Our most celebrated geometricians of the Academy of Sciences are aware of this; and, for some years past, they have been struck with the great scientific movement observed in Germany, as we have ourselves been by the progress made in teaching the applied sciences. We think that in respect to both these points there is a movement taking place in Germany to which France ought to pay serious attention.

M. Koristka, in his Report, also remarks at some length on the general constitution of the Polytechnic Schools.

They are, he says, children of our own time. They originally comprised the whole circle of technical subjects which every student was obliged to follow; but, as industry and industrial science extended, they were compelled, while retaining the general scientific instruction in common, to divide off the practical instruction into different technical branches, leaving the pupil to follow which of them he pleased according to his proposed destination. Thus arose the separate technical divisions now adopted in the Schools.

But, as almost all the technical branches have some connection with each other, it was found desirable to give the pupil in any special department some insight into the general nature of all the others, and so arose the encyclopædical lectures on the most important practical points of the various branches generally.

"Thus," says M. Koristka, "the present organization of the Polytechnic Schools may be summed up in a few words. They contain

"1. A general department of one or two classes, intended for all pupils in common.

"2. Four special departments for the four chief technical objects:

Constructive Engineering,
Architecture,
Machinery,
Chemistry;

in each of which the particular object is treated of thoroughly in several special courses, and the others more superficially in a general or encyclopædical course."

The information relating to the different countries is arranged in the following order:

- France.
- Belgium.
- Holland.
- Sweden.
- Russia.
- North Germany—
  - Prussia.
  - Hanover.
  - Brunswick.
  - Baden.
  - Würtemberg.
  - Saxony.
- South Germany—
  - Bavaria.
  - Bohemia.
  - Austria.
- Roumania.
- Switzerland.
- Italy.
- Spain.
- America—
  - United States.
  - Canada.

FRANCE.

The information obtained directly by the Council of the Institution, as to Engineering education, and the status of the Engineering profession generally, in France, is very copious and complete. Answers to their inquiries, some at great length, have been communicated from no less than seven independent quarters, the writers being all authorities of eminence, as will be seen by the following list of their names and official positions:—

1. General Morin, Member of the Institute, and Director of the Conservatoire Impériale des Arts et Métiers.
2. M. Gruner, Inspector of the École Impériale des Mines.
3. M. Combes, Director of the same establishment.
4. M. Schwebelé, Librarian of the École Impériale des Ponts et Chaussées.
5. M. Eugène Flachat, Civil Engineer of eminence, Honorary President of the Institute of Civil Engineers of France.
6. M. Wilhelm Nordling, of the Chemin de Fer d'Orleans.
7. Mr. W. B. Buddicom, an eminent English engineer, long established and practising in France.

Although these several communications necessarily contain some repetitions, yet from the great eminence of the Authors, and on account of the different points of view from which they have regarded the subject, as well as in acknowledgment of the trouble they have taken to give the required information, it has been thought expedient to give the papers entire.

This course is the more desirable because it is in France that the theoretical education of the Engineer has been carried out to the farthest extent, in the fullest detail, and with the most careful consideration. France has, indeed, in this particular, been taken as the example for the Continent generally, most of the educational systems of other European nations being based, more or less, on the French model. Hence the ample discussion, under varied points of view, of the nature and effect of the French Institutions is of peculiar interest and importance in the general inquiry.

The communications referred to will now follow in the order named: they have all been translated from the French, except that of Mr. Buddicom.

I.

LETTER FROM GENERAL MORIN, MEMBER OF THE INSTITUTE, AND DIRECTOR OF THE CONSERVATOIRE IMPÉRIALE DES ARTS ET MÉTIERS.

To Mr. James Forrest,
Secretary, &c.

Paris, 31st July, 1868.

SIR,

In your letter of the 7th inst., you have asked me to furnish to the Institution of Civil Engineers some information on the subject of technical education in France.

I have the honour to send you, by post—

I. A note published by me, in conjunction with M. Tresca, " Sur l'organization de l'Enseignement industriel."[1]

II. My report, " Sur l'organization de l'Enseignement industriel en Allemagne et en Suisse."[1]

III. " Rapport de la Commission de l'Enseignement technique," with various notes.[1]

These documents will, in some degree, answer your inquiries; but I will add some supplementary observations in the order followed in your questions.

First, nearly all the Civil Engineers of this country are educated at the " École Centrale des Arts et Manufactures." The Engineers of *Mines*, of the *Ponts et Chaussées*, and of the *Constructions Navales*, come originally from the École Polytechnique, and receive their professional instruction in special schools.

Second, the École Centrale at present belongs to the State, but it is carried on by its own resources, which suffice for all its requirements.

Third, the accompanying programmes of the studies, and of the conditions of admission to the École Centrale, will answer your third question.

Fourth, there are no text books compulsorily made use of in the different schools; the professors, for the most part, publish the autographs of their courses.

Fifth, the diplomas are given in the name of the State.

Sixth, very few Engineers receive their training in offices or manufactories, and these seldom inspire the same confidence as the others.

Seventh, practical knowledge is, in general, only obtained by the Engineer after he has obtained his diploma, and according to the various functions he has occasion to discharge.

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[1] See page 70. All these works are in the Library of the Inst. C.E.

Eighth, the accompanying documents will, as far as possible, answer your eighth question.

M. Tresca, to whom you have addressed this same inquiry, requests you will consider this answer as the only one he himself could furnish.

If, on any given point, you require further details, we shall have pleasure in procuring them for you,

Receive, Sir, &c., &c.,
(Signed) A. MORIN.

II.

COMMUNICATION FROM M. GRUNER, INSPECTOR OF THE IMPERIAL SCHOOL OF MINES.

Answers to the Questions proposed by the Institution of Civil Engineers of London.

I. SYSTEM OF EDUCATION FOLLOWED IN FRANCE FOR TRAINING CIVIL ENGINEERS.

The title of Engineer is not, in France, an official title, conferred by a diploma or brevet. The first comer may assume this title, in the same manner as the first comer may assume the title of Professor. For this it is not necessary to pass any fixed routine of School examinations or practical tests. But although a person may become an Engineer without passing through any special School, nevertheless the greater number of French Engineers come from the following Schools:—

1. The École Polytechnique; with the École des Mines, and the École des Ponts et Chaussées; which may be considered as annexed thereto.
2. The École Centrale des Arts et Manufactures.
3. The École des Mineurs at St. Etienne.
4. The École des Arts et Métiers at Chalons, Aix, and Angers; and the École des Maîtres-Ouvriers-Mineurs at Alais.
5. The Écoles Industrielles at Mulhouse, Lyons, Lille, &c.

All these establishments, except those in No. 5, are under the direction of the State. In the greater part of them the instruction is gratuitous. The École Centrale forms the sole exception, because it was originally founded by a private association, and only came into the possession of the State some years ago.

Young men who desire to enter one of the Special Schools above named, have to undergo, as a preliminary test, a series of competitive examinations (*concours*), preparing themselves in the various public primary or secondary schools (colleges, Lycées, or private institutions) which exist in all French cities.

1. *The École Polytechnique, and the École des Ponts et Chaussées, and the École des Mines.*

The most important examination is that imposed on the candidates for the École Polytechnique. The programmes of admission and of the course of instruction will be found in the accompanying works.[1]

Although the Polytechnic School depends on the department of the Minister of War, and is especially the nursery of the Corps of the Génie (Military Engineers) and of the Artillery, it is not a military school. The studies there are purely scientific; they embrace the higher mathematics, mechanics, physics, chemistry, geodesy, astronomy, &c. By these *general* studies, the students are prepared for the *special* studies pursued afterwards in the "Schools of Application." These are, for the Génie and the Artillery, the École Militaire at Metz; for Civil Engineers, the École des Mines and the École des Ponts et Chaussées in Paris. The two latter alone have to be treated of here.

These two Schools depend on the department of the Minister of Public Works; having been specially founded with a view to the service of this department. In them are formed the Ingénieurs des Mines and the Ingénieurs des Ponts et Chaussées, who remain in the service of the State. It must be added, however, that these two Schools, particularly the School of Mines, receive also other pupils, natives of France or foreigners, who study there with a view to private practice. These latter receive, on leaving the School, and after having passed severe examinations, Brevets or Diplomas which certify to the knowledge acquired.

Documents giving the particulars of the *régime* of these Schools accompany this Paper.

Among these is one with the title "Cours Préparatoires," on the subject of which a few words of explanation are necessary.

The courses of study of the École des Mines assume the pupil to be in possession of the knowledge to be acquired at the École Polytechnique; but the majority of the young men who study at the School of Mines do not come from the École Polytechnique; and hence it has been necessary to institute for them a "preparatory" course of study, comprising the most essential parts of that followed at the Polytechnic School.

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[1] *Vide infra.*

2. *École Centrale.*

The École Centrale was founded, about 1830, by an association of *savans* (MM. Dumas, Perdonnet and others), without any connection with the State. It remained so for thirty years, and has largely contributed by its pupils to industrial development in France. Since 1860, this School has been acquired by the State, and it is now assimilated to the Special Schools, placed under the direction of the Minister of Public Works.

The essential object of the Ecole Centrale is to train Engineers for private industry.

The instruction is very varied, but comprises specially all which has to do with the Chemical Arts, and the Arts of Construction. A large number of manufactories and of industrial establishments are now managed by former pupils of this School.

The conditions of admission, the plan of the studies, the form of the diplomas, &c., are given in the accompanying documents.

3. *École des Mineurs de St. Étienne.*

This School was founded in 1818, in substitution for the École Pratique des Mines, at Geislautern (Rhenish Bavaria). Its special object is to train Engineers as directors of Mines and Iron Works. The instruction is more elementary and more practical than at the École des Mines at Paris. The majority of Engineers who undertake the management of the Coal Mines in France, come from the School of St. Étienne.

Documents respecting it are enclosed.

4. *École des Arts et Métiers.—École d'Alais.*

The special object of these Schools is to train foremen or working managers (*contre-maîtres*) for Factories, Workshops of Construction, and Mines. The majority of French locomotive engine drivers, and many of the foremen in the French machine shops and iron works, come from these Schools—the most distinguished of them have even become Engineers or managers of iron works.

The instruction in these Schools is more practical than theoretical. At Alais the pupils work in the mines, as workmen, for half the year.

In the Schools at Chalons, Aix, and Angers, the pupils are exercised at the practical works of forging, lathe-work, fitting, wood-work, &c.

See the documents relating to these Schools.

In Paris, the public courses of the Conservatoire des Arts et Métiers are also specially intended for the class of foremen or head workmen of the manufactories of the capital. These courses are public and gratuitous. Programmes are given.

5. *Écoles Industrielles at Mulhouse, Lyons, and Lille.*

These have been founded by the municipalities, with the spontaneous assistance of the chief manufacturers of the cities. Each of these schools has specially in view the particular industry of the city where it is established.

The most important of these schools is that of Mulhausen, where both Chemists and Engineers are trained. At Lyons and Lille they are rather superior primary schools for the children of workmen and foremen.

Explanatory documents are annexed.

II.—Books used in the Schools mentioned.

In general the courses of instruction are in no wise based upon books. In some establishments the professors cause to be written out, for the pupils, the *résumé* of their lectures; but this measure is not general, and is never obligatory. This system is not followed either at the École des Mines at Paris, or at the École des Mineurs at St. Étienne; but it is practised, at least partially, at the École Polytechnique and at the École Centrale. Several professors have published works on the matters which they teach, but these are very seldom a reproduction of the courses themselves.

III.—As to the system of Apprenticeship.

There is nothing in France resembling the *pupilage* of English Engineers, except in the offices of architects.

The young men, when they leave the schools, learn the practical part of their profession by being attached, for one or two years, to some important industrial enterprise, as supernumeraries, draughtsmen, or sub-engineers. In the two latter capacities they receive pay; but as volunteers they are simply admitted into the workshops without remuneration. But in no case is there demanded from them any apprenticeship fee.

As above explained, the schools deliver, after examination, brevets, or diplomas; but many persons assume, in France, the titles of Engineer, Civil Engineer, or Professor, without ever having gone through any special tests. The law gives no prescription on the question.

(Signed) L. Gruner,
Inspector of the École des Mines.

Paris, 29th July, 1868.

III.

THE FOLLOWING NOTES ARE ADDED TO M. GRUNER'S COMMUNICATION, BY M. COMBES, HIS COLLABORATEUR, DIRECTOR OF THE ÉCOLE DES MINES.

The École Polytechnique is, in reality, as M. Gruner says, a School of the Mathematical Sciences, and not a School of Engineers. The programmes of study there are essentially the same as those of the division of sciences in the superior normal school. It is found that, almost every year, many young men who have come out of the school in the first ranks, and have been classed for the service of the Mines, or that of the Ponts et Chaussées, have abandoned these careers, in order to follow that of teaching, in the Lycées, the faculties of Sciences, or in the École Polytechnique itself.

The attempts made, some years ago, to impress on the studies of the École Polytechnique a character less exclusively abstract, and approaching more nearly to practical ideas, have not been successful. The level of the general instruction has been lowered, while the pupils have not acquired any important or exact knowledge of a practical nature. They evinced, moreover, but little taste for this new kind of study, to which neither the professors nor they themselves could devote the necessary time. This therefore has been abandoned.

The pupils of the École Polytechnique are boarded and lodged in the establishment. About 120 to 150 are admitted per annum, out of a number more than sextuple of candidates who present themselves. Five-sixths of these therefore find themselves excluded after three years of special study, at the end of numerous examinations which fatigue them extremely, and which, after all, in spite of the talent and the conscientious impartiality of the examiners, only give a doubtful decision between those who are at the end of the accepted list, and those excluded.

The Corps of *Ingénieurs de l'État;* of Mines, Ponts et Chaussées, and the Génie Maritime (naval constructions), are exclusively recruited from the students of the École Polytechnique. To each of these three services corresponds an École d'Application, situated in Paris. In these the student Engineers pass three years; they are not boarded or lodged, but receive from the State a moderate allowance of 1,800 francs (£72) per annum. The instruction has for its object in each school the applications of the physico-mathematical sciences to the special constructions of mines, roads and bridges, ships, machines, &c.; and the branches of the natural sciences which have to do with the functions of the special Engineers. At the École des Mines, for example, analytical chemistry, mineralogy, geology, palæontology. The students acquire practical instruction in the laboratories of the establishment, on works out of doors, and by travelling in France and abroad, the expenses of which are defrayed, at least in part, by the State.

Along with the Élèves Ingénieurs there are also admitted to the École des Mines, and to the École des Ponts et Chaussées, a certain number of home and foreign pupils, called *Élèves externes.* These participate in the same studies and exercises as the Élèves Ingénieurs; they compete among themselves, and receive, on leaving, a diploma or certificate. They pay no fees. The number of Élèves externes admitted to the School of Mines, after competition, is from twenty-five to thirty annually.

The École d'Application du Génie Maritime receives also students authorised to follow the course.

(Signed) CH. COMBES,
Director of the École des Mines.

11th August, 1868.

IV.

LETTER FROM M. SCHWEBELÉ, LIBRARIAN OF THE ÉCOLE DES PONTS ET CHAUSSÉES.

École Impériale des Ponts et Chaussées.
Paris, 14th July, 1868.

DEAR SIR,

I am highly honoured in being asked for a memorandum on the organization of the general system that obtains in France for the education of Engineers. I am free to avow that the question is a very delicate one. I shall, withal, do my best to give you as exact an idea as possible of that which is known in France as the instruction of an Engineer.

As you are doubtless aware, the Engineers intrusted with civil constructions are divided into two very distinct bodies:

1. Government Engineers; Corps des Ponts, Corps des Mines.
2. Civil Engineers.

The Engineers to whom the State confides the execution of its works are chosen exclusively from among the pupils leaving the École Polytechnique. These pupils, after a stay of three years at the École des Ponts et Chaussées or des Mines, are appointed Engineers of the Corps des Ponts et Chaussées or des Mines. These bodies, of which more hereafter, are organized by virtue of imperial decrees, and form a part of the Government establishment in France.

The Civil Engineers, on the contrary, are entirely free from the control of the Government. They are educated either by entering at the École Centrale, or by attending the different public courses, notably those of the École des Ponts et Chaussées.

This class has no official status (*caractère*), and is never called upon to take charge of Government works. The majority of the young Engineers who choose this branch of the profession are employed by the railway companies, in factories, or in industrial capacities.

As you will perceive, we are now considering the two classes of Engineers which constitute nearly all those in France whose avocations connect them with public works.

The question is, therefore, what are the results of these two systems of general instruction? Be it my task to enable you to appreciate the value of each.

In a general way, the Engineers of the Corps des Ponts et Chaussées de France are subjected to the routine which I shall now proceed to indicate.

1. Complete courses of study in the 'Lycées' of the empire, for the results of which see programme No. 1.

2. Admission into the École Polytechnique, after examination on the subjects in programme No. 2.

3. Drafting of the pupils, for two years, to the École Polytechnique, where the subjects taught are those in programme No. 3.

4. Out of 150 pupils the first 20 enter the École des Ponts et Chaussées, where they pass three years, and are again subjected to numerous examinations. See programme No. 4.

On leaving the École des Ponts et Chaussées the pupil will probably be twenty-three or twenty-four years old. Then, after classification, he is appointed third-class Engineer, and attached to some departmental service under the orders of a Chief Engineer, himself a past pupil of the College.

You will observe that by these means all the Engineers eventually arrive at one common standard, with a professional education at once solid, profound (*sérieuse*), and, above all, uniform. There results from this a considerable *esprit de corps*, which may doubtless have its drawbacks, but which has also great advantages, resulting in the conscientious discharge of the duties, and tending to the honour of the Corps des Ponts et Chaussées.

It is not easy to enter into the details of the education of our young men. It will, I think, suffice to direct your attention to the several programmes numbered 1 to 4. The successive examination of these programmes will put clearly before you the chain of acquirements which our pupils are expected to possess before leaving the École des Ponts.

Touching the instruction peculiar to the École des Ponts et Chaussées, it is divided into three parts:

1. Common lessons in the amphitheatre.
2. The preparation of designs (*rédactions de projets*) and chemical manipulation.
3. Excursions in fine weather to the works of the department.

It would require time to detail all these operations. I think that an examination of the programmes 4, 5, and 6, will be sufficient to enable you to form an opinion on our system of internal instruction.

In order that you may consider the whole of our system of public works, I have included in my parcel the pamphlet No. 7, comprising the decree of the 13th October, 1851, on the organization of the Corps des Ponts et Chaussées. No. 8 relates to the official administration of the École des Ponts et Chaussées. In document No. 9 will be found all the details of the internal working of the school, of the classification, the discipline observed, &c.

I think it well to inform you that side by side with our pupils, already requited by the State, may be found young men who bear the title of 'external pupils' (*élèves externes*), and who fulfil the same conditions of study as the pupil engineers (*élèves ingénieurs*). These external pupils receive, at the expiry of a term of three years, a diploma of 'past pupil' of the school (*ancien élève de l'école*). The pamphlet No. 10 will show the conditions upon which these young men are received into the school.

You possess, now, all the elements necessary to understand our school in its essential details. I am at your service for information regarding their practical development. It is not possible for me to foretell this in advance.

Thus far we have only considered the course of study of the École des Ponts et Chaussées, that is to say, the instruction given to Government Engineers. It remains to give you a general idea of the system of instruction for Civil Engineers practising privately.

In France the majority of these are educated at the École Centrale des Arts et Manufacture. This school, established by Perdonnet, is now managed by the State. The fee paid for studying is £32 (800 frs.) per annum.

From what you wrote, I understand that you have forwarded to all the schools or institutions in France a duplicate of the circular which you did me the honour to address to me; I do not, therefore, consider it necessary to enter fully into the details of the École Centrale. Suffice it to give you a few succinct explanations, such as will enable you to appreciate the difference between the two schools.

In principle the École Centrale renders very valuable services to further the end which it proposes to attain. The young men who are destined for this school, founded upon the system which is called in France 'Special Instruction,' enter it, for the most part, with very fair acquirements, but without any uniformity. This want of uniformity in the preparatory instruction of the pupils presents very grave inconveniences; and I must avow that it is the principal point that needs reform.

After three years in the École Centrale the pupils leave with a diploma or certificate, the one relating to constructions, the other to machinery.

Practically, the studies at the École Centrale are very good; theoretically, they lack a solid (*sérieuse*) foundation. This want of basis results, as I had the honour to observe before, from the want of uniformity in the preliminary instruction of the pupils. The consequence is, that the position of the Government Engineers is far superior to that of their unofficial brethren. All the higher scientific offices are generally occupied by past pupils of the École Polytechnique, be it as Professor, Member of the Institute, &c. It but rarely happens that a Civil Engineer gains an elevated position in a scientific point of view. I would add, to give greater value to my assertion, that many of the professors of the École Centrale are chosen from the past pupils of the École Polytechnique.

Kindly note, Sir, that on this subject my opinion is perfectly unbiassed. I have no reason to be animated by what may be called the *esprit de corps*, quite on the contrary. I am not an engineer, and my only desire is to make known to you the truth. You may therefore consider that what I have had the honour to tell you is the true reflection of public opinion on the two categories of engineers.

I have abstained from speaking of the Military Engineers. These Engineers are called in France the 'Corps du Génie.' The officers of this corps also come from the École Polytechnique, and they finish their studies at the École de Metz. You have, moreover, a similar body in England. In France the officers of the 'Génie' have nothing to do with public works, being exclusively charged with the construction of works incidental to the military art, such as barracks, hospitals, fortifications, &c.

I believe that I have now replied to nearly all the questions contained in your programme. Should it be otherwise, I am altogether at your disposal. Write to me, and kindly indicate precisely those points which seem to you to need explanation.

Be pleased to receive the assurance of my very devoted sentiments.

(Signed) ED. SCHWEBELÉ,
Librarian of the École.

28 Rue des Saints Pères.

V.

The following is by M. Flachat, the eminent Civil Engineer.

On the General System of Professional Education for Engineers in France (excluding the Military Branch of the Profession).

Intervention and patronage of the Government. Preparatory Studies. Professional Schools for Engineers. Programmes of Admission. Diplomas. Practice of the Profession. Its future prospects. Parts taken by the Government and by private enterprise in the encouragement of the Profession of Engineering.

Down to 1830, when the École Centrale des Arts et Manufactures was founded, the sole instruction for the engineering profession was given, in the École des Ponts et Chaussées and the École des Mines, to a certain number of pupils coming from the École Polytechnique (Note A). This school, founded in 1794 under the name of the École Centrale des Travaux Publics, was at first intended to train Engineers, but the military activity of that time soon led to a departure from that course, and for a long time its principal destination was to prepare pupils for the special instruction they were to receive in the two schools of the Génie and the Artillery at Metz. But the administrative constitution of France, founded under the Empire, assigned to the State, either as a matter of construction or control, the execution and the management of the various public works affecting the internal communications of the country (Note B), the working of mines, the superintendence of vehicles of all kinds, of steam-boats and steam-engines, the regulation of streams serving as motive powers for manufactories, and the establishment of manufactories themselves; in a word, not only all which in our modern society is of common use, either gratuitous or otherwise, but also the control of industry in general. In order to fulfil these important functions, it was necessary to have agents possessing technical instruction of the highest kind; this was a condition of the general interference of the Government in the industrial affairs of the country.

The École des Ponts et Chaussées and the École des Mines (Note C) were then founded, their students being chosen from the most meritorious pupils of the École Polytechnique. Having become, at the time of leaving, agents of the Government, these functionaries soon acquired an elevated rank in the administration, by the prestige due to their instruction and to an ardent and exclusive *esprit de corps*, which has preserved them from influences that, under various *régimes*, have lowered, in public estimation, the moral level of other branches of the public administration.

From 1800 to 1825 there were, in France, no other Engineers than those who came from the two above-named schools dependent on the administration. The profession of the Civil Engineer was neither recognized nor exercised. It did not exist in private industry, and the interference in the works of the State of individuals trained elsewhere than in the State schools would not have been possible, as these works belonged absolutely to the active domain of the State.

The hierarchical organization of the official Engineers was as follows:—

1. In the first rank came the Inspectors, general and divisional, forming the General Council, and divided into special sections. These functionaries were charged individually with inspections over districts occupied by several sections of Engineers in chief, among whom the country was divided.
2. The Engineers in chief of the first or second class.
3. The ordinary Engineers of the first, second, or third class.

The ordinary Engineers of the third class were first called 'aspirants;' then 'élèves,' during the period of their gradation, which was three years, and which was replaced by missions in the course of the studies.

The promotion of the Engineers is by selection or by seniority, according to certain rules.

The duration of the instruction at the École Polytechnique is two years, that of the special instruction at the Écoles des Ponts et Chaussées et des Mines is three years. These three years comprise eighteen months of missions on works.

The preparatory instruction given at the École Polytechnique has comprised, from its foundation, the mathematical sciences, drawing, physics, chemistry, mechanics, hydraulics, &c., as well as the general sciences, astronomy and geology. The pure science acquired in this school exceeded then, and exceeds much more now, the notions necessary for the special schools of Ponts et Chaussées and of Mines (Note D). But far from being disadvantageous, this was the germ of an intellectual development, most rapid and most elevated, for the choicest scholars, and to this must be attributed the large number of *savants* who have come from this school.

The admission to the Polytechnic School is by public competition, and to this liberal and democratic measure, as well as to the scientific success of some pupils, is due the popularity the school has enjoyed from the time of its foundation.

The Bachelor's degree in Science or Literature (*Baccalaureat ès sciences ou ès lettres*) is required for admission to the competition. The programme of the competition has undergone developments analogous to that of the instruction itself. It comprises now the whole of arithmetic, the elementary and part of the complete instruction of geometry, algebra, trigonometry and descriptive geometry, physics, and general chemistry. After 1870 a knowledge of the German language will be requisite for admission.

These sciences are undoubtedly within the reach, to the required degree, of the intelligence, memory, and judgment, of pupils from eighteen to twenty years of age. This would perhaps have seemed difficult twenty years ago, but the modes of instruction have progressed with the sciences themselves; greater method, clearness, and simplicity have been introduced in their exposition and demonstration, so that the memory has been relieved of a useless burden, and the judgment more powerfully appealed to. It is probable that, in proportion as literary instruction, instead of, as now, fettering scientific studies by the time which it absorbs, shall serve as a preparation to them, the programmes of admission will demand yet more in the way of pure science.

The military services which are recruited from the Polytechnic schools are the Artillery, for land and sea, the Génie, military and maritime, the Imperial Navy, the corps of Hydrographical Engineers, the Commissariat of the navy, and the *Corps d'état major* of the army.

The civil services, of which the Engineering *personnel* is recruited exclusively among the students of the Polytechnic School, are the Ponts et Chaussées and the Mines, the manufactures of the State, and the lines of telegraph.

But the separation of the two classes (military and civil) is no longer so absolute in the actual exercise of the profession as this classification would seem to indicate. A certain number of Military Engineers abandon the profession of arms in order to enter into an industrial career; Engineers of the Artillery and of the Navy give themselves up in the workshops and ship-yards of the Government to studies and labours by which industry profits. As the Government has demanded hitherto but little competition from private enterprise in the manufacture of the arms, the ships, and the engines of the Imperial Navy, it follows that important establishments are directed by State Engineers, who seek to follow, if not to advance, the progress of private industry in works of the same kind.

The instruction in the special schools of the Ponts et Chaussées and Mines has, for its object, the application of the sciences to public works, to the working of mines, and to the treatment of mineral matters.

This range of scientific applications becomes more extensive every year; it includes not only the public services, but nearly all large industrial enterprises. The constant tendency of the State being to substitute its action for that of private industry in the public services, as well as in the industrial enterprises which are connected with any political or fiscal requirements, it will be seen how important is the basis of the education given by the State to its pupils, and what a multiplicity of details it involves. (Note E.)

In the terms of the special programme for the École des Ponts et Chaussées, the instruction comprises "the construction of roads, bridges, railways, canals, harbours, the improvement of rivers, civil architecture, applied mechanics, hydraulics, the steam engine, agricultural hydraulics, the geological and mineralogical knowledge required in the arts of construction, administrative law, and political economy."

The pupils are exercised in drawing operations, in the preparation of designs or projects, the manipulation and testing of materials, levelling, mechanical drawing, &c.

For half the year they are sent away to employ themselves, under the direction of the chiefs of the service, in the practice of the art of the Engineer.

Besides the pupils destined for the public service, and recruited exclusively from the pupils of the Polytechnic School, the École des Ponts et Chaussées receives native or foreign external pupils by competitive examination on a programme of the required knowledge. The same is the case with the École des Mines.

The pupils who enter the public service from these schools do not receive any diploma; their status is acquired by the fact of the instruction they have received. But a diploma is delivered to the "externes" when they have passed their final examination.

On leaving these schools the Engineer enters active service; he goes to demand from observation the bond between what he already knows and the means of execution. It remains to him to learn the methods of manipulation; to appreciate the resources to be drawn from the workman; to judge for himself of the qualities of the materials; to learn the forms of accounts, the administrative formalities; to acquire the habitude of managing geodesical instruments; to direct his assistants in the study and the preparation of designs. This is what constitutes in reality the stage during which he remains Engineer of the 3rd Class. He is then directed by his chiefs and aided by an inferior staff of assistants, attached to every Engineer's service; and which is composed of clerks and accountants, of conductors of works, and of *piqueurs*, whose instruction, altogether special and generally limited in a scientific point of view, leaves to the young Engineer the moral superiority resulting at once from more extended theoretical ideas, and from his hierarchical situation. (Note F.)

The ordinary Engineer soon enters into his full rights and functions; and here also is recognised the liberal idea which has presided originally over the constitution of the École Polytechnique and the schools of application. This liberal idea consists in the freedom of initiation allowed to the ordinary Engineers. When a work is demanded from the Engineer-in-chief, he causes the study of it to be prepared by his ordinary Engineer; he may doubtless give to him the programme, and the subordinate is bound to conform to it; but if the latter thinks the programme of his chief defective or incomplete, he has the right to state his reasons and to present another design. The chief discusses the work of his ordinary Engineer, and adopts or rejects it, or proposes another solution; but he has no power to suppress it. The design is then sent on to the central Administration in order that it may be submitted to the Conseil Général des Ponts et Chaussées (Note F); it receives a preparatory examination in the sections of this council, and on their demand the Engineer-in-chief is called to defend his project before them.

The chief Engineer has no right to design work directly, or to execute a work, without the aid of his ordinary Engineer, thus passing him over; and the latter has no power to evade the direction of his chief for the study and the execution of works which belong to the service with which he is charged.

Down to 1825, the profession of the Engineer thus remained exclusively represented by the agents of the Government. As already stated, the entire possession of the public services by the State did not allow any other organization. This organization was founded on the establishment of the tax on works of locomotion, and consequently on the free use of the ways of transport. But about this time, the weakness of the State funds on the one hand, and the example of England on the other, led to great modifications in the system; some statesmen did not hesitate to adopt the remunerative principle for works which the budget could not charge itself with, and the interest of which appeared at first purely local. These were, toll-bridges, drainage and irrigation works, some few navigable canals, and finally railways. It was thus that the principle of concessions of public enterprises to private industry served to originate the free profession of the Civil Engineer. The first members were recruited from the ancient pupils of the École Polytechnique, or from industry itself; but there remained a very small number, perhaps in France a hundred Engineers, outside the Corps des Ponts et Chaussées and the Corps des Mines, when the École Centrale des Arts et Manufactures was founded.

This was in 1830. The school was originally an industrial enterprise; its founders had not in view the training of Engineers for the execution of public works; railways had hardly come into use; it was for private industry that they desired to train Engineers. But the coincidence of the foundation of the École Centrale with the introduction of railways had an almost immediate influence on the instruction. For not only did the creation of the great concessionary Railway Companies open a new career to Engineers, but the principle itself of concessions of public services being once admitted into legislation, the application naturally extended itself to other enterprises in which the association of private capitalists might be advantageously substituted for the funds of the State.

Another stimulus less important also offered itself to the activity of free Engineers, namely, the establishment of municipal works, such as water-works, gas-works, and so on.

All this was not anticipated at the time of the foundation of the École Centrale des Arts et Manufactures, and yet it was to the construction and working of railways, and to industrial enterprises founded on the public service, that the pupils leaving this school applied themselves by preference. Civil Engineering has been more the result of the development of public works, by means of concessions or acts of incorporation (as they would be called in England), than of the progress of private industry. It is true that this state of things is daily becoming modified, industry appeals more and more to the profession of the Engineer, and the progress of the arts obliges the manufacturer to ask his assistance. The teaching of the École Centrale has answered to these two kinds of need. Although in pure science it is less advanced than that of the École Polytechnique, it is more extended in the arts of application than that of the École des Ponts et Chaussées or the École des Mines. The constructive, mechanical, and metallurgical arts are more laboriously taught there than in the École des Ponts et Chaussées; but it is inferior in the special instruction obtained in the École des Mines, where mineralogy and assaying are carried much farther.

With regard to the arts and mechanical processes, the direction of the instruction given at the École Centrale has been followed by very happy results, in the sense that mechanism has been rapidly introduced into the arrangements of building yards, by the intervention of the Engineers who have come from this school. Down to that time, the Engineer had left to the contractor the care and the responsibility of such arrangements.

In proportion as the system of concessions of public works to private enterprise has opened to the Engineer a vaster field, and as industry has created great centres of production, the public opinion has gone in favour of the profession. Already the Government had opened to external pupils, by competition, the schools of the Ponts et Chaussées and of Mines, and delivered the diploma of Engineer to the students leaving them. It had created the École des Mines at St. Étienne, and that at St. Alais: one destined to educate Engineers and other officers for the direction of mines and metallurgical establishments; the other to train chief mining workmen. And finally, when the École Centrale des Arts et Manufactures was offered by its founders to the Government, they did not hesitate to take possession of it. (Note H.)

The instruction for the profession of Engineer has thus come entirely under the management of the Government.

It is carried on in five schools, namely—

The École Polytechnique.
The École des Ponts et Chaussées.
The École des Mines.
The École Centrale des Arts et Manufactures.
The École des Mines de St. Étienne.

The expenses are borne by the Treasury, and they amount annually to 835,700 francs (33,428*l.*). A note of the details is given below.[1]

The first of these schools is preparatory, but the instruction in pure science given there is complete. The State draws from it the *personnel* it requires for the public service, and distributes the individuals into the special schools, of which some train military officers, and others Engineers. This school receives about one hundred and fifty students per annum. Few of these fail, and therefore it may be estimated that a nearly equal number leave the establishment with the conditions of aptitude necessary to enter into the special schools.

The mean annual number of students who have left the École Polytechnique to enter the various special Engineering Schools are as follows:—

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[1]	Francs.
École Polytechnique	664,000
„ des Ponts et Chaussées	71,800
„ des Mines	83,200
„ Centrale	453,980
„ de St. Étienne	16,700
	1,289,680
Deduct the proceeds of the fees paid by the Students of the École Centrale	453,980
Total	835,700

Besides the reimbursement of its expenses the École Centrale leaves a nett annual profit of 70,000 to 80,000 francs per annum.

The receipts in the École Polytechnique, which amount to 1,000 francs per student per annum, should be deducted from the 835,700 francs.

—	Civil Services.	External Pupils of the two Schools, École Centrale des Arts et Manufactures.
École des Ponts et Chaussées	17	10
„ des Mines	3	18
„ des Mines de St. Étienne	..	20
„ Centrale des Arts et Manufactures	..	130
Total	20	178

The composition of the active *personnel* of the engineering profession coming from the Government schools is at present as follows:—

33 Inspectors-General.
225 Engineers-in-Chief.
525 ordinary Engineers.
About 2,500 Engineers who have come from the École Centrale.
„ 400 Engineers, external pupils of the École des Ponts et Chaussées and the École des Mines.

The pupils of the École Centrale receive, on leaving, a diploma of Engineer, or a simple certificate of capacity. This diploma expresses the speciality in which their studies have been principally conducted—construction, machinery, metallurgy, or chemistry. The external pupils of the École des Ponts et Chaussées, and of the École des Mines, receive similarly a diploma. The number of students leaving these schools without a diploma or certificate is generally very few, because they are allowed, under certain conditions, to renew their studies. (Note K.)

It remains to speak of the Engineers who have not received their instruction in the State schools.

In France the profession of the Engineer is free, any one who pleases can call himself Engineer; it is open like all other industrial professions. Hence there are educated Engineers, and Engineers who have had no theoretical instruction.

Some of these latter are accepted because they have acquired their knowledge in the practice of some speciality. Experience and acquaintance with practical works, particularly in the construction of machines, a distinguished cast of mind, good education, and an honourable reputation, have often sufficed to give a good rank among Engineers to men happily endowed with these qualifications, but who have had but a limited theoretical instruction. In general self-made men are received with a certain good nature, and this is unanimous when they have acquired, in the course of their career, the theoretical ideas directly necessary for their labours. It is thus that a certain number of students of the

Écoles des Arts et Métiers, of conductors of the Ponts et Chaussées, of foremen of workshops, and so on, have acquired the uncontested title of Engineers.

In proportion as scientific instruction shall enter into general education, no doubt private industry will furnish a contingent to the Engineering profession more and more considerable, which will be a strong stimulus for the professional schools. These, in consequence of the generality of the studies, can only treat briefly of the application of arts and sciences to manufactures; so that the duration of the period passed by the certified student in industrial works increases in proportion to the difficulties presented to him by the speciality into which he enters on leaving the school, and in possession of which he finds men solely taught by experience.

It is probable that the reunion in Paris of the professional and official Engineering schools will have the result of creating a mode of affirming by a diploma the knowledge of the profession, analogous to that which exists in England. The patronage of an Engineer having a certain standing, accompanied by the certificates of University professors as to the student's knowledge of the theoretical sciences taught in the schools, will be the basis of the diploma, which, being a direct emanation from private industry without official sanction, will be received according to the merit and the standing of the persons who sign the diploma. This is very desirable.

As to the future of the profession, it will probably follow the development of labour and the progress of science. Engineers whose acquirements are limited to a comprehensive system of general principles, must fail in regard to the multiplicity of details required by each special branch of the profession. General instruction, as soon as it leaves pure science, that is to say, when it extends itself widely to applications, becomes a cause of impoverishment to special instruction. The title of Engineer may be adopted as the general indication of many technical professions which have only one bond between them, that of the pure sciences, and which can only be normally practised by the aid of these sciences.

Will the whole organization, administrative and industrial, of the profession of the Engineer, in France, produce as fertile results, and as rapid a progress as that which has taken place in England, in the absence of all official regulation, and of all Government sanction, either in instruction or diploma? It is difficult to believe so: to be useful, a profession ought to follow social wants, to modify itself according to them, to transform and adapt itself, in a word, to their interests of activity and of well-being. On the contrary, the peculiar quality of State institutions is stability, tradition, immobility, in legal or official forms. Already, before the discovery of railways, the distinction between French and English Civil Engineering was considerable: private industry was in England at the head of all great enterprises; in France it had a hand in none; science could effect nothing against the lack of opportunities to work, against the want of stimulus to create and to perfect; and it was private industry which in France came, with the railways, to elevate Civil Engineering, to rouse it from its apathy, and to raise it to the level to which it has now attained.

Experience, in default of reasoning, would tend then to demonstrate that, if it is the duty of Governments to render all the aid they can to professional education, for the services of general control with which they are charged in the public interests, they ought also to be equally careful not to trammel by any exclusive measures the efforts of industry to train its own professional agents: they ought even to encourage these efforts, to excite competition in the instruction, and in the exercise of duties analogous to those which they give to their own agents.

When, as in England, private industry offers to Civil Engineering the great and only field for the application of its activity, it becomes evident that the sanction of the State is useless for the diploma of its Engineers. In this case there doubtless is a less elevated means of pure scientific instruction, but the technical value of the *ensemble* of the profession is higher, and it renders greater service to the public welfare.

If, as in France, the State shares with private industry the direction of public works, it ought on its part to take care that the education of its agents is beyond question: it is further just and liberal that it should authorize private industry to draw its instruction from the same sources of education, by external study. And further, if according to the customs of the country all instruction is obtained through scholastic establishments with their degrees and diplomas, it is proper that the Government should do for the profession of the Engineer the same as they do for letters, pure science, law, medicine, &c. It would seem, then, that in what already exists in this respect there is nothing to be destroyed; and that it only remains to extend it to the efforts which private industry may make in a direction analogous to and independent of the Government. (Note L.)

EUGÈNE FLACHAT,
Honorary President of the Société des Ingénieurs Civils de France.

October, 1868.

NOTES.

These notes emanate from an Ingénieur en Chef des Mines, one of the most distinguished for his scientific attainments, and for his practical works, both in the public service and in private industry.

NOTE A.

Before 1830, as at present, there were external pupils at the École des Mines; some came out of the École Polytechnique, the others, but very few, were admitted after examination. At the École des Ponts et Chaussées external pupils have only been admitted for the last few years.

NOTE B.

It is only exceptionally that the State has worked mines: under the First Empire a coal mine near Sarrebruck, and lead mines in Savoy, as connected with the practical Mining Schools existing at these places; and under the Restoration, the salt mines of the East.

NOTE C.

The École des Mines of Paris was created in 1778, closed in 1790, reopened in 1794; see the Law of 22nd October, 1795 (Loi concernant les Écoles des services publics). This law places the School under the authority of the Minister of the Interior, recruited from the École Polytechnique and admitting external pupils. The School was reorganized on the same principles by an Ordonnance of the 5th December, 1816. The same law of October, 1795, organized the École des Ponts et Chaussées, which had existed before the Revolution. The chief object of this School was to train Engineers; the military element only became predominant at a later period.

NOTE D.

For an Engineer who grows dull in the ordinary service, a part of the instruction becomes useless. For an Engineer who works, all portions of this instruction may, at any moment, be serviceable; and, besides, they are necessary in order to follow the courses at the special schools. The necessity, at the present day, of a high instruction in physics (telegraphy, heating, lighting, moving powers, &c.), and above all, in chemistry, is incontestable; the differential and integral calculus and mechanics are indispensable when it is desired to approach the questions of metallic or other construction. The instruction at the École Polytechnique is necessary to enable an Engineer to treat, in a complete manner, all the questions arising in his profession; it is sufficiently advanced to serve as a point of departure for philosophers of the future.

The Civil Engineers leaving the École Centrale have learnt, in a less complete or more superficial manner, all that is taught at the École Polytechnique, and it is possible for them, by personal study, to attain the same level of scientific knowledge as the students of the latter. Examples of this are not wanting.

NOTE E.

Some reserve should be made on this point. The tendencies of Government, of high administration, are different from what is generally believed. In what concerns private industry properly so called, whenever an industrial regulation is meddled with, it is in the direction of less State intervention, as in the case of mineral interests, smelting furnaces, steam engines, and the conditions of their manufacture and testing; unhealthy manufactories (de-classification, or lowering of the classes).[1] In regard to Railways, where the credit of the Companies has been rested on that of the State, and where important monopolies are placed in the hands of a small number of Companies, it ought to be borne in mind that the hand of the State presses very lightly on them. The same is the case with the enterprises of the transatlantic steamers.

One of the most liberal measures of Government has been the purchase of the École Centrale, which it cares for, encourages, and develops in the interest of free industry. It is the same view which has induced the State to develop more and more the external tuition in the School of Mines; to create that of the École des Ponts et Chaussées; to augment the Écoles d'Arts et Métiers, &c.

As to the control over industry, England has gone much further than France, in the intervention of the State; in the latter country no efficacious or applicable law yet exists as to the work of children in factories.

NOTE F.

The relative independence of the ordinary Engineer is not only a liberal measure, it is an effective control as regards both art and finance.

It would be well to say something of the *Agents-voyers.* The tendency to decentralization, the extension of the powers of the Prefects or of the Conseils-Généraux, cause these officers to become real Ingénieurs des Ponts et Chaussées, their standing becoming constantly more and more elevated; and they are recruited constantly more and more from the École Centrale.

NOTE G.

I believe that the teaching of metallurgy is much less developed at the École Centrale than at the École des Mines; and the same for the art of working mines. I further believe that the instruction at the École Centrale has a defective feature, namely, the spreading of the instruction over subjects too varied; the same young man working with equal assiduity at the École des Mines and the École Centrale, would acquire at the former an instruction less varied, more special, but more substantial; and he would, I believe, be better prepared to embrace the majority of the professions recruited from the École Centrale. It is wrong to seek to make of the École Centrale a rival to the special Schools of Mines; that might be explained by the circumstances of its origin, but it is not justifiable now. The École Centrale ought to be solely the special school of public works and of manufacturing industry (from which I would not exclude metallurgy, as I would the art of the miner). If it is to trench on the domains of the other schools, it would do better to occupy itself on the one hand with agriculture, and on the other with architecture.

NOTE H.

The École des Mineurs at St. Étienne is equivalent, as regards the degree of instruction, to the École Centrale; but the School of Alais is of the same order as the Écoles d'Arts et Métiers, and I believe even lower. None of the acts constituting the St. Étienne School speak of *Garde-Mines:* they are recruited by special examination to some extent from all quarters.

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[1] M. Flachat does not agree in this opinion. If the most enlightened men follow this path, the great majority of the agents of the public administration take an opposite course. The increase of the power of the State during the last seventeen years has tended to an increasing absorption, by the Government, of industrial activity.

NOTE I.

Here may be mentioned the École du Génie Maritime, established at Paris, and to which it would be doubtless useful to admit external pupils, as, for example, such pupils of the École Centrale as might wish to devote themselves to the construction of ships. A valuable instruction is given there which is not sufficiently utilized. There is also the École des Manufactures de l'État, Tobacco, Gunpowder and Saltpetre. This School has become of importance since the service of the gunpowder of commerce has passed into the hands of the Minister of Finance. There is here a nursery of manufacturing Engineers, which from time to time may furnish individuals to private industry.

The number of 150 pupils leaving the École Polytechnique is too large. Generally less than 150 enter, and illness and interrupted studies reduce the number leaving the School to 120 or 130, omitting exceptional years of special military requirement.

NOTE K.

At the École des Mines, if the pupils who arrive at the end of their course fail, they are not allowed to renew their study.

NOTE L.

My conclusion would be that in England, where the enormous extension of industry and commerce, resulting from the natural mineral riches of the country and the conditions of insular existence, has already developed on a great scale the profession of the Engineer, there is nevertheless a great deficiency of theoretical instruction, which it is essential, in a national point of view, to supply.

I believe that in this study agricultural industry should have been made to participate; under another form this requires to have recourse to the art of the Engineer, and calls into action a knowledge of the mineralogy and geology of the soil, the chemical fabrication of manures, the mechanical and chemical elaboration of the produce, the mechanics of labour, construction, irrigation, drainage, meteorology, &c. There are many schools in which superior farm-servants are trained; but the profession of agricultural Engineer is in a great measure yet to be created. Things are at present in the same state as regards agricultural industry as they were for manufacturing industry in 1830. The question was raised in 1848, and the two years of action of the Institut Agronomique of Versailles produced good results, but naturally very limited. The Government has felt the necessity that something should be done; and it is said that the Commission instituted on this subject have arranged a programme for the opening in Paris of a school of high agricultural instruction, which would be to this branch of industry what the École des Mines is to mining.

I believe that the pupils of the École Centrale, possessing their language of general technical instruction, who would be willing to follow for two years the special courses of a school of this kind, might render themselves very useful in this new career.

The instruction of the two Schools might be combined in such a way that the pupils of the École Centrale might afterwards pass these two years at the School of Agriculture. It is further probable that the same combination might be adopted as at the École des Mines, where there is for the external pupils who do not come from the École Polytechnique a preparatory course, putting them rapidly in a position to follow the special instruction.

Taking the question in general terms in the point of view of the actual organization of the professional schools in France, a system might be adopted which is, I believe, that of Germany. It would be possible to combine in a preparatory school (which would only be the extension of that of the École des Mines) the general and common instruction necessary to approach the special education—descriptive geometry, drawing and colouring, physics and chemistry, the elements of the differential and integral calculus, graphical and topographical delineation, &c. This would be the École Polytechnique abridged, with the instruction strictly necessary given in one year instead of two.

Pupils admitted on examination to this preparatory school would be received after examination in the four Schools of Application, Ponts et Chaussées, Mines, Arts et Manufactures (reduced to two years of special instruction), Agriculture. These same pupils might also enter the section of Architecture in the École des Beaux Arts, where a good foundation of special instruction would be very useful to them.

M. Flachat accompanies his communication by a letter, of which the following is a translation :

"October 15th, 1868.

"I REPLY, after much delay, to your letter of 8th July, by sending you the accompanying memoir on the questions proposed in your circular respecting the system of education adopted in France for the profession of the Engineer. In that memoir I have confined myself to description; I have not wished to enter on comparison.

"In my opinion, free industry forms the most *useful* engineers; this is the state of things in England. Government education, on the other hand, makes them more learned (*savans*); this is the case with our École des Mines, recruited from the École Polytechnique. Our École des Ponts et Chaussées has not been rich in *savans*, because the functions of the Engineers coming from that school have long been, and still are, very limited, and all emulation has been extinguished in them.

"I believe our system is much too centralized to suit England. It is desirable that each of your large towns should have a faculty composed of professors, whose united certificate should form the diploma; the diplomas should be of different degrees; the first for preparatory education, analogous to that of the École Polytechnique; the second for special education—construction, metallurgy, mechanics, mines, agriculture, architecture.

"The pupils might follow their studies while they were engaged in industrial occupations; these would have to devote longer time to study than those who occupied themselves exclusively with it, but they ought to be able to succeed equally well.

"I express here an opinion, concurred in by all the Engineers who have visited England; *viz.*, that the necessity, for that country, of extending the ideas (*de répandre les notions*) of the engineer is in proportion to his industrial activity. Wherever a scientific faculty could be maintained by a centre of population, at least for preparatory education, there should be no hesitation. The faculties for special education are more difficult to establish because the professors are but few; but you would have enough for a dozen establishments. A most useful rivalry would establish itself among them; it would be entirely moral, and, for the most part, disinterested; but it would not therefore be less ardent.

" Several causes have delayed this little work; a journey of two months, and the examination of my memoir by one of my friends who has been for thirty years in the first rank of the Corps des Mines; he is free from all prejudice, though more inclined than myself to the opinion that the intervention of the State ought to predominate both in education and in public works. I have the greatest confidence in his opinion because it is most enlightened and sincere, but I do not absolutely concur in it.

" From year to year I have always felt my conviction increase, that private industry ought to be the sole instrument of activity for all the wants of a nation, and that the State, representing more exclusively the general interest, ought only to exercise a control. On this account, private industry ought to contain within itself more science, more originality, more means of action than the State. But the State, in exercising its control, ought to borrow from industry the men most distinguished by character and by science which have been trained thereby. Industry alone appears to me capable of training men whose mission should be, when age and experience have fitted them for it, to guide, continually, the activity of the country into the path of the general interest. Such men alone would have that moral influence which is the sole means of coercion when interests are concerned so varied, and mixed up so inextricably with the manners and customs of the labouring population. From this point of view, I believe, that every State which, like ours, would create a tribe of Levites—a special corps—charged to direct the activity of the country, must always be in the rear of those who prefer to demand, from industry itself, its own counsels.

"These ideas are far removed from those prevalent in France, but they accord well with those held in England. The truth is, that if science is equal in the two cases (or rather is more advanced and more general with us), art advances with you at a pace much more rapid. We have been imitating and following you for sixty years; and the French Engineer who ignores what is done by you, has but an incomplete acquaintance with his profession. If science were more generally spread with you, you would maintain your superiority.

(Signed) " EUGÈNE FLACHAT."

VI.

FROM M. WILHELM NORDLING, OF THE CHEMIN DE FER D'ORLEANS.

16, Place Vendôme, Paris,
July 16, 1868.

SIR,

Our director, Mr. Thirion, has intrusted to me the task of replying to your circular of the 7th inst. I shall confine myself to that which concerns this Company, being convinced that you will receive, as regards the schools and official bodies of France, information from more competent sources.

The network of the Orleans Company comprises, 4,000 kilomètres of lines, of which about 3,000 kilomètres are open, and the rest in course of construction. Its administration is at present divided into three nearly distinct parts, viz.:

The lines already at work, under the directorate of Mr. Solacroup, with the staff necessary for the trains, the maintenance, and the reconstruction and extension of the works.

The western network having Mr. Morandière for its director, including the lines in construction in Bretagne, Vendée, Poitou, &c.

Lastly, the central network having Mr. Thirion for its director, and comprising the lines in construction in Auvergne, Bourbonnais, Limousin, &c.

The technical staff (*personnel technique*) of this triple administration has a common origin, but varied, viz.:

1. The Imperial Corps des Ponts et Chaussées and des Mines, and the Imperial Schools of the same name.

2. The Imperial Écoles des Arts et Métiers of Châlons, of Angers, and of Aix.

3. The conductors and auxiliary employés of the administration des Ponts et Chaussées.

Herewith are some observations on each of these three categories.

The Imperial Corps des Ponts et Chaussées is exclusively recruited from among the young men who, by public competition, have passed the École Polytechnique and the École des Ponts et Chaussées. It comprises, by law, all the Engineers' appointments at the disposal of the Government for the maintenance and the construction of highways, canals, river navigations, seaports, the construction and supervision of railways, &c. The Engineers of the Ponts et Chaussées cannot enter the service of the railway companies without the consent of the Government, which, for this purpose, accords them an 'unlimited leave' (*congé illimité*). If the period of this leave exceed five years, the rights of promotion and of seniority are surrendered.

The Orleans Company employs at present fifteen Ponts et

Chaussées Engineers, who fill the highest posts; those of directors already mentioned, of Engineers-in-chief of construction and maintenance, of resident Engineers (*ingénieurs ordinaires*) for new works as well as for maintenance.

The organization of the Imperial Corps des Mines is similar to that of the Ponts et Chaussées. the members are recruited from the École Polytechnique and the École des Mines. It devotes itself to the Government supervision of mines and partly to the working of the railways. The Orleans Company employs but one Ingénieur des Mines.

The Imperial Écoles des Ponts et Chaussées and des Mines.—For some years these two schools have admitted, under the title of 'free scholars' (*élèves libres*), a certain number of pupils, as many foreigners as natives, who receive the same instruction as the pupils drafted from the École Polytechnique, and destined for public duties. On leaving, the foreign pupils naturally return to their own countries (principally the South American Republics, Portugal, Spain, Germany, &c.). The French 'free scholars' are not entitled to employment in public offices, and have much difficulty in obtaining private appointments. The Orleans Company employs but three or four, one of whom is a Chief Engineer.

The École Centrale furnishes a large number of employés to all the companies. We have some who are resident Engineers, Engineers in charge of sections of works in progress (*chefs de section*), assistants, draughtsmen, &c. They prevail above all in the locomotive and rolling-stock department (*service du matériel et de la traction*). The École Centrale often complains of the competition of the Corps des Ponts and des Mines, mostly in respect of the superior grades.

The three Imperial Écoles des Arts et Métiers furnish practical assistants, who are well up in iron-work (*le dessin et le travail des métaux*). They are to be found in all departments; and if the majority do not succeed in raising themselves above inferior and mediocre positions, some, notwithstanding, attain the highest grades.

The administration of the Ponts et Chaussées employs under its Engineers a numerous staff of conductors, *piqueurs*, and auxiliary servants, some of whom come from the École Centrale, some from the Arts et Métiers, and lastly, some of whom simply train themslves in the offices and on the works. A public examination, open to all, decides on their admissibility to the Government employment in question.

For some time the *conducteurs* of the Ponts et Chaussées were absolutely shut out from the office of Ingénieur des Ponts et Chaussées. Under Napoleon III. the legal disability has been diminished, but in reality it has not yet been removed.

Many conductors of the Ponts et Chaussées have obtained from the Government leave of absence, and have entered the service of the railway companies as resident Engineers (*ingénieurs ordinaires*), Engineers in charge of sections, conductors, &c.

The English system of pupilage obtains in France only with architects. No French Engineer exacts, nor possesses the power of exacting, any fee for such knowledge as the young men may pick up in his office or on his works. Supernumeraries are sometimes taken, who at the outset are not paid, but this is still a rare exception. The young men leaving the public schools have made sufficient sacrifices, and have, as a rule, sufficient professional knowledge to merit remuneration.

The style of 'Civil Engineer' is in France so badly defined that any and every one may assume it; and it does not in any way apply to the Government Engineers (Ingénieurs des Ponts et Chaussées and des Mines). Formerly the past pupils of the École Centrale took the title of Civil Engineer; now, their diploma styles them Engineers of Arts and Manufactures (Ingénieurs des Arts et Manufactures).

The title of Civil Engineer would appear more and more to associate itself with the members of the Société des Ingénieurs-Civils, a private society, whose organization assimilates to that of the Institution of Civil Engineers in England.

(Signed) WILHELM NORDLING.

VII.

FROM MR. W. B. BUDDICOM, CIVIL ENGINEER.

Note on the various Schools for Engineers in France.

THE various schools opened in France for the instruction of pupils destined to be Engineers are under the direction of Government, payment being made of an annual sum, also of an entrance-fee representing the value of the outfit required by each pupil. These being paid, the Government engages itself to defray all expenses connected with furnishing instruments, the emoluments of professors, &c.

These general expenses are regulated by the various ministerial departments in whose hands these institutions are placed, and appear in the Budget of the State.

There are two kinds of Engineers, the Government Engineers and Civil Engineers.

The *Government Engineers* must first pass through the École Impériale Polytechnique before being admitted to an École d'application. They receive there general theoretical notions suited to all careers, but no practical instruction. The regular school-time having expired, the pupils are classed according to the year's marks, the half-yearly examinations, and general examinations. At the last examination the pupil names in order of preference those careers he would prefer entering, and he is classed in the one in which there is room for him, according to his rank; so that his career depends not only on the rank taken by him at the last examination, but also on the number of places given each year by Government. The number of these places is of course much smaller than the number of candidates admitted each year, but the Government, in all its nominations to positions, gives preference to students of the École Polytechnique. This privilege is of much importance, for thereby the entry to many civil employments is facilitated.

Generally speaking, the non-military Government employments are classed as follows:—

Mines, Ponts et Chaussées, Génie Maritime (constructions navales), Les Tabacs, Telegraphs, &c.

Generally, appointments to the "Mines" do not exceed the first ten, and the Ponts et Chaussées the number thirty. Those pupils which are received on leaving the École Polytechnique and classed according to merit, are then sent to the various Écoles d'application suited to them, viz., the future mine Engineers to the École Impériale des Mines, the future Ingénieurs des Ponts et Chaussées to the École Impériale des Ponts et Chaussées, where they receive the theoretical and practical instruction necessary to them. After the regulation-time has expired, and when the pupil has been sent on mission to the departments, and attached to some works in course of execution, he becomes Ingénieur ordinaire des Ponts et Chaussées, and then Ingénieur en chef, and lastly Inspecteur Général.

There is no École d'application for the Génie Maritime (constructions navales). The pupil Engineers are sent to the military ports immediately on leaving the École Polytechnique, and at the end of a certain time they make a journey round the world, and return after that to the Government building-yards.

The "Government Engineers" can obtain "*congés*" (leaves of absence), during which they may place themselves with railway companies, or in private industrial concerns; and as these positions frequently procure them emoluments greater than their official pay, it often happens that at the expiration of their leave, which cannot exceed five years, they prefer not returning to the body of Government Engineers.

Civil Engineers.—The École Impériale Centrale des Arts et Manufactures de Paris has for its especial object the formation of Engineers for all branches of industry and public works, the management of which does not necessarily belong to the Engineers of the State. Each year the Minister of Public Works delivers to the pupils designated by the council of this school the following—

1. To those who have satisfied all the requirements of the public examination, diplomas of Ingénieur des Arts et Manufactures.

2. Certificates of capacity to those who have proved that on all the most important points of education they possess the necessary knowledge.

The diploma of Ingénieur des Arts et Manufactures gives no right to any official position, as the State reserves exclusively for its Ingénieurs des Mines and Ponts et Chaussées the numerous places it has at its disposal. But private industry, railway companies, and others, employ many of these Ingénieurs Civils, as in them are found the guarantees of necessary capacity, and they therefore thus frequently arrive at very high positions. Among Civil Engineers there is of course neither classification nor rank. Each individual must strive to create for himself a career through his own resources. On the contrary, the Government Engineers find immediately an assured position in which they advance successively, generally according to the order of merit in which they came out of the École d'application. The consequence is, that the admission to the École Polytechnique is solicited every year by a large number of young men, and that by reason of the comparatively small number of pupils admitted each year the conditions required, both at the entrance examinations and leaving examinations, become more and more difficult.

After what has just been said, it will be easily understood that a sort of rivalry exists between the two corps. The Government Engineers, full of the prestige which the École Polytechnique has given them, look with a certain feeling of superiority on the Civil Engineers. These, on the other hand, consider that the former have too much theoretical and too little practical knowledge. Consequently very little amalgamation exists between the two corps, who on each side keep up among themselves, even long after having left the schools, a laudable spirit of fraternity.

The Society of Civil Engineers in Paris is proud of counting amongst her number all the celebrities of industry, without respect to their nationalities.

Besides the various categories of Engineers which have just been mentioned are the following:

The conducteurs des Ponts et Chaussées are divided in three classes, viz.:—

Les conducteurs et sous-ingénieurs des Ponts et Chaussées, which are appointed by Government by examinations of capacity.

The conducteurs principaux. Les conducteurs de première, et de seconde classe.— The title of sous-ingénieur des Ponts et Chaussées can be conferred on 'Conducteurs principaux,' who, for five years, at least, have held the position of Engineers and exercised their functions.

The École des Mineurs de St. Étienne, which is destined to the formation of Engineers for the direction of mines, and establishments for working metals, as well as of assistant engineers of mines.

Also for the civil employments—

Les Écoles Impériales d'Arts et Métiers at Aix, at Angers, and at Chalons-sur-Marne, destined to the formation of foremen, and of instructed and clever workmen for the trades where metal and wood are worked. The instruction there is both theoretical and practical, and at the termination of their studies, those pupils who have satisfied the requirements of the final examinations receive a certificate.

The school of the Maîtres-ouvriers Mineurs of Alais gives to the two-years-pupils, who are considered worthy of it, a diploma of Maître-Mineur (master miner).

In short, there are two completely distinct categories.

The Government Engineers having been forced to pass through the École Polytechnique are spread (by order of merit) over the various Écoles d'Application suited to the career, under Government, to which their number has destined them. These situations are salaried by Government, and assured during lifetime (excepting in very rare cases of dismissal), and so make it possible for the holders to arrive at high administrative positions.

The Civil Engineers, to whom the State only grants Engineer diplomas, certificates of capacity, &c., which diplomas enable them to embrace, in private industrial concerns, careers which are, at least, as honourable, and often more remunerative, but especially much more independent, than those to which the Government Engineers arrive. It is generally at the 'École Centrale,' or at the schools of Châlons or Angers, that the heads of industrial establishments apply for the young Engineers or foremen they may be in want of. The large engineering firms (railway and others) employ as draughtsmen or engineer-pupils many of the young men from the above-named schools, who come to them to complete their practical education.

All these different schools are placed in the department of either the Minister of War (for the École Polytechnique) or of the Minister of Commerce and Public Works, and receive subventions from the State (with the assistance of the towns and departments), and are entirely at its (the ministère's) charge; minus the annual contributions stipulated from each pupil and expenses of outfit, &c.

Public examinations are required at the entrance and on the leaving of each pupil, according to published programmes fixed upon by ministerial decrees. The examiners are chosen exclusively among the notabilities of the Government corps of instruction.

The conditions of admission and quitting become every year more difficult by reason of the affluence of candidates. And in consequence of this principle of admission by competition, a number of colleges and private institutions (these latter conducted either by laymen or religious fraternities) prepare bachelors of science and pupils for Government schools of all sorts.

Public free lectures are given by the most eminent professors of the Sorbonne, the College de France, and at the Arts et Métiers. Also public and free evening lectures destined especially for workmen, and established in all quarters of Paris under the patronage and control of the Minister of Public Instruction and of the town of Paris.

As an example of the knowledge which is required for admission to the following schools, printed programmes are enclosed, viz., for admission to the

École Impériale Polytechnique.
„ des Mines.
„ des Ponts et Chaussées.
„ des Arts et Manufactures.
„ d'Arts et Métiers.
Emplois de Conducteurs et Sous-Ingénieurs des Ponts et Chaussées.

The following can be procured at "A. Morant, Libraire des Écoles, Rue de la Sorbonne, 22, Paris:" The compositions for examinations at the École Polytechnique, at the École Centrale, etc., with the detailed questions and problems given.

Price for each separate school:—

	Fr.	c.
Examinations of 1866	7	50
„ 1867	15	0

Enclosed is also a prospectus of M. Morant, relating to his various publications as connected with the different schools, and which will be useful in case you may wish to obtain any of them more than those I send with this.

I should add, in reply to your question about the premium paid by pupils to Engineers, that such a practice does not exist in France.

W. B. Buddicom.

Gonbodw, Sept. 25, 1868.

SPECIAL INFORMATION RESPECTING THE VARIOUS FRENCH ENGINEERING SCHOOLS.

In addition to the general details contained in the foregoing communications, other information has been obtained, bearing more particularly on the various Special Schools; and a large number of published documents have been received, which are preserved for reference in the Library of the Institution. This information will now be given, and reference made to the published works, under each head.

ÉCOLE POLYTECHNIQUE.

See the following Works.

Programmes des Conditions d'Admission à l'École Impériale Polytechnique. Année 1868. Paris, Delalain. Small 8vo.

(The same for 1866 and 1867. Folio.)

Programmes des Connaissances Exigées, et Instruction Ministerielle pour l'Admission à l'École Impériale Polytechnique, en 1868. Paris. Hachette. Small 8vo.

Programmes des Connaissances Exigées pour l'Admission à l'École Impériale Polytechnique en 1863; arrêtés par le Conseil de perfectionnement, et approuvés par le Ministre de la Guerre. (Extrait du Journal Officiel.) Large 8vo.

Programmes de l'Enseignement Intérieur de l'École Impériale Polytechnique; arrêtés par le Conseil de perfectionnement, et approuvés par le Ministre de la Guerre. Paris. Imprimerie Impériale, 1866. Large 4to.

Copy of the form of Certificat de Capacité, given on leaving the school.

ÉCOLE DES PONTS ET CHAUSSÉES.

See the following Works.

Décret portant Organization du Corps des Ponts et Chaussées. 1867. 8vo.

Décret portant Organization de l'École des Ponts et Chaussées. 1867. 8vo.

Programme des Conditions d'Admission à l'École des Ponts et Chaussées. Paris. Delalain. Small 8vo.

Règlement intérieur de l'École Impériale des Ponts et Chaussées. 1867. 8vo.

Programmes de Enseignement intérieur de l'École Impériale des Ponts et Chaussées; arrêtés par le Conseil de l'École, et approuvés par le Ministre de l'Agriculture, du Commerce, et des Travaux Publics. Paris. Thunot. 1867. Large 4to.

Admission des Élèves externes aux Cours de l'École. Décrets, Arrêtés, et Décisions. Paris. 1864. 8vo.

Note indicative des principaux Ouvrages à consulter à la Bibliothèque, pour l'examen de Droit administratif. 4to.

Programmes des Concours—Session 1867-8. Folio.

Form of Diploma for the Élèves Externes. Folio.

Journal de Mission. Various papers and forms. Folio.

Programme des Conditions d'Admission aux emplois de Conducteur et de Sous-Ingénieur des Ponts et Chaussées. Paris. Delalain. Small 8vo.

École des Mines.

The following particulars in reference to this School have been furnished by M. Combes, Inspecteur Général des Mines, and Directeur de l'École des Mines. M. Combes says in his accompanying letter—

"We have no detailed programmes of the course of study of this School. Each of the professors arranges, with great freedom, the order of his instruction, and the extent which he gives to each part thereof; keeping within the limits of the number of lectures allotted to him from the 15th November to the 15th April following.

"In order to supply, as far as possible, the place of these wanting programmes (which would, moreover, necessarily vary with time and the progress of science), I send along with the printed papers a manuscript notice; at the conclusion of which is a list of works published by some of our professors, Messrs. Rivot, Couche, and myself."

Notice respecting the Course of Study at the École des Mines, Paris.

From 9 to 11 A.M., the students attend the three following Courses:—

1. Working of Mines and Machines.
2. Metallurgy.
3. Docimatie (Assaying).

Each of these Courses consists of from forty-two to forty-five lectures in the year, of two hours each.

The Course No. 1 comprises for the first year, working of mines, for the second, machines. The former treats of the search for mineral veins, by digging and boring; of the formation of shafts and galleries; of the working properly so called; of ventilation, drainage, &c. The Course of Machines comprises—prime movers, by wind, water, and fire, &c.; machines for extracting, for exhaustion; blowing hammers; rolling machinery, &c. Finally, the Course comprises also the mechanical preparation of ores and fuel.

The Course No. 2, Metallurgy, treats, the first year, of the subject generally, and of iron; the second year, of all other metals. In the first year fifteen lectures are devoted to the subject generally, *i.e.* to fuel, furnaces, and metallurgical processes, and twenty-five lectures to cast and wrought iron, and steel. The second year, three lectures to a revision of the general subject; then thirteen or fourteen lectures to the metallurgy of copper; eighteen to that of lead and silver; three to gold, platinum, and mercury; and six or seven to tin, antimony, bismuth, cobalt, nickel, and zinc.

The Course No. 3, of Assaying, treats, the first year, of the alkaline, alkaline-earthy, and earthy metals and metalloids, and the analysis of their compounds; the second year, of the ordinary metals and the analyses of their natural and artificial compounds.

From noon to 2 P.M. the pupils of the first year follow the Course of Mineralogy, and those of the second year that of Geology; each of these is composed also of forty lectures.

The same pupils follow, together and during the two years, the Course of Palæontology, comprising twenty lectures each year.

In the interval between the lectures, and in the afternoon, the students work, by turns, in the laboratory, and in the drawing-saloons.

In the evening they have lessons in the English or German languages.

The pupils of the third year follow three Courses; the principal one, consisting of forty to forty-five lectures, of two hours each, relates to construction in general, and comprises more especially the establishment and working of railways. The two other Courses of twenty lectures each treat, one of administrative law and legislation as applied to mines; the other, of the principles of agriculture and of drainage, as applications of the Course of Geology.

In summer, the pupils are exercised the first year in drawing plans and in chemical analyses; the second and third years in practical studies in the mines and works. Reports and memoirs have to be furnished by the pupils on these several subjects.

NOTE.—Professor Rivot has published his Course of Assaying and Professor Couche, his Course of Construction and Working of Railways.

The other Courses are not published; but the "Traité de l'Exploitation des Mines," by M. Combes, formerly Professor of Exploitation and Machines, may be referred to.

Some further information will also be found in the following note, supplied (through Mr. J. Arthur Phillips, of the Widnes Metal Company) by Professor Rivot.

The programme of the course of instruction in the École des Mines is not yet published, but it will soon be so; meantime I give you some details respecting the admission and the number of pupils.

The greater number of the external pupils pass one year in the preparatory course of general chemistry, mechanics and mathematics, descriptive geometry, carpentry, physics, &c. Three professors, each two lectures per week, for six months.

The candidates pass a preliminary examination before an Ingénieur des Mines, and afterwards a final examination before the three professors of the cours préparatoires. The knowledge required is nearly the same as for admission to the Polytechnic School.

At the end of the course there are held three examinations, at intervals of fifteen days. Those who have less than twelve marks on an average are excluded; those who have more than twelve are admitted to pass in November the examinations for admission in that year. From thirty to thirty-five students are received annually to the cours préparatoires; of these twenty to twenty-five obtain more than twelve marks at the examinations at the end of the course.

During the year the student Engineers enter directly, according to their rank at leaving the École Polytechnique, about three student Engineers per annum.

The external pupils are received by examination before a commission of professors, named by the council of the school. The knowledge required is that of the cours préparatoires; in substance all that is taught at the École Polytechnique. Lately twenty-four external students have been received per annum, which I consider too many.

There are also foreign students, five or six per annum, admitted at the request of their ambassadors, and without examination. It is for them to prepare themselves properly to follow the instruction with profit.

Student Engineers, external pupils, and foreigners, are all treated alike as regards instruction, laboratory, drawing, examinations.

There are three years of studies and practical exercises.

First and second year.—Lectures twice a day; assaying, exploitation, metallurgy, mineralogy and palæontology; laboratory and drawing alternately in series of three weeks from 15th November to 15th April; then examinations to the end of May. Those who have not twelve marks, on an average, are excluded.

After the examinations of the first year, two months of laboratory, June and July, six weeks of study of plans, and a short journey in France.

After the examinations of the second year, a tour in France or abroad for one hundred days.

The third year, studies of railways, legislation, drainage, laboratory for two series of three and four weeks, analyses, notes of the journals and memoirs of the tours, projects of metallurgy and exploitation. After the end of the course, in the month of May, examinations on the three courses, notes given for projects, journals, memoirs, &c. Final classification.—All those who have not twelve marks, on an average, only receive a certificate of study, signed by the inspector of studies; those who have more than twelve obtain the diploma of Civil Engineer, signed by the minister. About fifteen diplomas are given to the external pupils each year.

In addition to the external pupils and the foreigners there are some free students, who have permission to follow the courses and nothing more. (Signed) Rivot.

See also the following Works.

Institution et but de l'École. Small 4to.

Extrait des Réglements de l'École Impériale des Mines. Small 4to.

Programmes des conditions d'admission aux Écoles des Mines. Paris. Delalain. Small 8vo.

Cours Préparatoires. Programme des conditions et des connaissances exigées pour l'admission aux Cours Préparatoires. 8vo.

Élèves externes. Programmes des conditions et des connaissances exigées pour l'admission aux places d'Élèves externes. 8vo.

Form of Certificat d'Études. Small folio.

Form of Brevet for Élèves externes. Small folio.

Articles on the School, in the 'American Journal of Mining,' August 8th and 15th, 1868. Large folio.

École Centrale des Arts et Manufactures..

A large amount of useful information on French educational institutions will be found in the Report of the French Commission of 1863 (Translation, p. 285 *et seq.*)

The admirable account, written by M. Perdonnet, of the chief establishment for training Civil Engineers, the École Centrale, has such an important bearing on Engineering education that the following large extracts are presented from it:—

Account of the Central Imperial School of Arts and Manufactures.

Object of the School.

The Central School of Arts and Manufactures, founded in 1829 by three then youthful votaries of science, MM. Dumas, Péclet, and Ollivier, aided by M. Lavallée, who zealously co-operated in the work, is not yet so highly appreciated as it ought to be. It plays, without any parade, a most important part in our educational system—a part still underrated by a great number of persons. It has quietly rendered signal services, and is destined to render still greater—a fact we will endeavour to demonstrate.

In 1829 manufactures, thanks to several years of profound peace, were beginning to assume great importance in France; but to struggle against foreign competition, daily becoming more formidable, it was not enough to possess good workmen and intelligent overseers, skilful engineers were likewise wanted. The manufacturers, moreover, felt the necessity of themselves acquiring or of obtaining for their children that theoretical knowledge without which they were unable, not only to direct their establishments themselves, but also to control the managers whom they engaged for the purpose. At that time there was no school where industrial science could be acquired.

The Sorbonne, the Conservatory of Arts and Trades, the schools of Châlons and Angers, though very useful institutions, answered the purpose but very incompletely. They did not impart that accurate and profound instruction which is necessary for the directors of large manufacturing establishments and indispensable for Civil Engineers.

The Schools of Arts and Trades supply our workshops with young men who promptly become excellent overseers; but the theoretical studies are not sufficient to form skilful engineers. Some few remarkable men have indeed proceeded from these schools, but they were of the sort who will learn wherever they may be, and rise to celebrity just as well from the dust and smoke of the workshop as from the benches of a schoolroom.

The Central School, therefore, cannot be compared for the services it renders either to the Sorbonne, or to the Conservatory of Arts and Trades, or to the other technical schools. It remains to be seen whether it is not an unnecessary duplicate of its elder sister, the Polytechnic School, and this question we will now examine.

The Polytechnic School was founded at a time when political revolutions had thrown scientific studies into the background. Its object was to give those studies new life, to impart a common direction to the labours of scientific men, to concentrate on one point efforts till then unconnected; in short, to supply our corps of engineers, civil and military, with the well-taught recruits they so much needed. And it has nobly fulfilled its mission. The Schools of Mines, and of Bridges and Roads completed the work undertaken by the Polytechnic School.

But the time required by the Polytechnic School, including the preparatory and complementary studies, is seven years, which is much too long for candidates who are anxious to begin practice as soon as possible. The difficulties of the examination for admission also exclude a large proportion of candidates: the consequence is that the number admitted every year is very limited. It shuts its doors against many hundreds of young men whose minds, though little disposed for mathematical abstractions, are none the less capable of studying the applied sciences. More than half its pupils choose the military service, and of the other half a good part soon abandon the civil services to follow scientific pursuits. The Polytechnic School is therefore far from being able to satisfy the ever-increasing demands of industry. There is good reason to fear that if the pupils of the Polytechnic School were left free to choose between the posts offered by private industry and those reserved for them by the Government, the cleverest of them would give the preference to industry, which assures them positions, if not more honourable, at least more liberally remunerated; hence might result great prejudice to the State. The Government seems to be aware of this, for it has already forbidden its engineers to serve any other companies but those for railways.

The Central School, therefore, supplies a manifest deficiency in our system of instruction. Its function is to educate our leading manufacturers and the directors of our great industrial establishments; while the mission of the Polytechnic School is more especially to supply properly qualified recruits for the special corps. The success it obtained from the very first, a success every day increasing, sufficiently proves its immense usefulness.

Notwithstanding its high charges, and the fact that it does not, like the Polytechnic School, offer its pupils any assured position on the completion of their studies, the Central School has found, in presence of other establishments where instruction is gratuitous, the number of candidates for admission constantly increasing, and to such an extent that not more than half of them can be received. The late treaties of commerce have rendered industrial education more necessary than ever. "If the Central School did not already exist," says M. Michel Chevalier, "it would have been indispensable to found one as a necessary complement of those treaties." Moreover, it is a tradition in the school that its foundation was originated with a view to preparing French manufacturers, by a sound education, to pass without any violent shock from a system almost prohibitive to one of limited protection.

In all the branches of industry the pupils of the Central School have taken honourable positions. They stood in the first rank among the creators of railways, and some of them, notwithstanding the formidable competition of the Government Engineers, still hold important positions under the great companies. At Paris the chief engineers of the rolling stock and locomotive department of four great companies (the Northern, the Orleans, the Eastern, and the Western) belong to the Central School. In the mining and metallurgical industries, in those of gas, spinning, dyeing, paper making, plate glass manufacture, in the agricultural arts, and, lastly, in all the mechanical and chemical industries, we find at the head of large establishments old pupils of the Central School, who have nearly all attached their names to important improvements in the processes they were charged to conduct.

The above statement is fully proved by the following figures:—of the 2,051 pupils who obtained on leaving the school the diploma of engineer or the certificate of capacity we have been able to obtain precise information respecting 1,394 only. Of this last number we learn that 247 are dead, and that the 1,147 still living are distributed in different careers in the following manner:—

Railways:—Directors and chief engineers, salaries from 20,000 to 70,000 fr.	28	320
Principal engineers, salaries from 10,000 to 20,000 fr.	79	
Ordinary engineers, salary from 5,000 to 10,000 fr.	56	
Employed in various capacities	157	
Civil engineers in general practice		166
Ironmasters, working of mines, quarries, &c.		124
Manufacturers of cloth, cotton, linen, &c.		68
Architects		55
Mechanical engineers, established		54
Spinners		43
Professors of applied sciences		42
Manufacturing chemists		38
Agriculturists		37
Contractors for public works		35
Managers of gas-works		31
Sugar-refiners		28
Public functionaries		26
Manufacturers of glass, porcelain, &c.		23
Engineers of bridges and roads in foreign countries		22
Paper-makers		17
Surveyors of roads		17
Total		1,146

Organisation of the Teaching.

In organising the Central School its founders took for their model the old Polytechnic School (Central School of Public Works), with the modifications required by the object they had in view. For instance, they excluded from the curriculum everything connected with mathematical theories of too high an order, experience having shown that the said theories have but few practical applications.

At the Central School, as at the Polytechnic, the pupils are obliged, whatever may be the career they have chosen, to attend all the courses and to pass very strict examinations. The young men are thus prepared to follow almost any profession. It is, in fact, by no means unusual to see young engineers, on leaving this school, successfully pursue a different career from that originally chosen. At the Polytechnic School this generality of instruction extends to the theoretical studies only, since the pupils at the end of the three years' course are sent to one or other of the special schools to complete their education. At the Central School the instruction is purely theoretical in the first year only; in the second and third, theory and practice are blended.

The founders of the Central School justly remarked in their first prospectus:—"All the courses of the school really form but one and the same; industrial science is one; every manufacturer must know the whole under pain of being inferior to the rival who enters the lists better armed than himself. Arts apparently widely differing from each other make use of analogous operations, yet often employ very different methods. The general education of the Central School teaches how to transfer into each process of manufacture the improved methods used in others. It consequently tends to introduce into industrial establishments, and into the details of the processes or of the mechanisms, a degree of perfection which secures the harmonious working and general success of the whole." This was a noble and prolific thought; it has produced abundant fruit.

The studies of the Central School may be thus briefly recapitulated:—

In the first year pupils follow the course of descriptive geometry with applications; analysis, comprising the elements of the differential and integral calculus; cinematics, general mechanics, general physics, general chemistry, construction of machines, and hygienics.

In the second and third year courses of applied mechanics, construction and putting up of machines, analytical chemistry, industrial and agricultural chemistry, constructions (civil buildings, public works, and railways), applied physics and steam engines, metallurgy, mineralogy, geology, and working of mines.

The course of construction of machines, which is very complete, as well as that of applied physics and steam engines, and the course of applied chemistry, are peculiar to the Central School. The teaching of mechanics is also conducted on a new plan, in a spirit essentially practical.

An accurate idea of the education given at the Central School may be formed from an attentive study of the new programmes. Whoever reads them will admit that if they have not yet reached perfection, they nevertheless present a well-ordered instruction useful to all who wish to pursue an industrial career.

The oral instruction of the Central School is judiciously completed by mposing on the pupils numerous studies of projects, by manipulations in he laboratory, by visiting workshops, by mineralogical and geological xcursions, and especially by frequent compulsory examinations, not only t the end of each year's studies, but also during the courses and at their lose. The pupils, in drawing out projects and in chemical manipulations, begin to apply what they learn in each course, and thus prepare for the more serious operations of practice.

At first the council of the school, when definitively classing the pupils according to their merits, took into account only the marks obtained at the final competitive examination at the end of the third year, when each pupil had to present a project on a given subject. But experience soon showed that a pupil who answered correctly the questions put at the examination was not unfrequently a very indifferent pupil favoured by a lucky chance. It was therefore decided that the average marks of the third year should be added to those of the competition in appreciating the merits of the candidate. As pupils were often found to be somewhat negligent in the second year, it was subsequently deemed advisable to carry this principle still farther, and take into account the marks of the second year in awarding the diploma or certificate of capacity, and in assigning the pupil his place in the list published in the *Moniteur*. With all these precautions, it is scarcely possible that there should be any great mistake in appreciating the merits of the pupils.

This fact seems to have been well understood by manufacturers, for most of them require candidates for employment to produce either a diploma or certificate, and as the latter is of less value than the former we every year see old pupils who have obtained certificates only, present themselves again to compete for the diploma.

The number of pupils admitted to the Central School in its first year (1829) was 147, but it fell to 45 in 1832, during the prevalence of the cholera, and has kept almost constantly increasing since. In 1840 it was 125; in 1845, 152; in 1855, 220; and from 1855 to 1863 it has ranged from 200 to 220. This last number is a limit we have never attempted to exceed, owing to want of room and other reasons.

Nothing can so well demonstrate the excellence of a mode of teaching as the results obtained, and these we have set forth as clearly as we could. It is interesting to compare the system of teaching at the Central School of Arts and Manufactures with that at the Polytechnic Schools of Germany and Switzerland. We will endeavour to make this comparison as concisely as possible.

The Polytechnic Schools of Germany and Switzerland (Hanover, Brunswick, Berlin, Dresden, Prague, Vienna, Munich, Stuttgart, Carlsruhe, and Zürich), are real technical faculties. The Zürich school is even more than that, since it has courses of political science, &c. The number of courses is considerable; they are extremely varied, and for the most part professed by very learned and talented men.

The pupils of all these schools are in no instance lodged and boarded on the premises. They are subdivided into auditors, or pupils who attend only such lectures as they choose, and regular pupils, who are obliged to attend a certain series of courses constituting a complete technical education, such as is required for builders, mechanicians, chemists, &c.; they also have to perform certain practical exercises in the chemical laboratory and workshops; in some places (as at Dresden and Berlin, for instance), they have to cease their theoretical studies for a time and leave the school to work under practical men, before they can enter on the concluding portion of their instruction at the schools. None of these Polytechnic Schools, except that of Zürich, grant diplomas to their pupils.

If we compare the programmes of these schools with that of the Central School, we shall find them very much alike as regards theoretical teaching; but as to applications a great difference exists.

The examinations on admission are much less formidable in the German schools than those which the pupils of the French Polytechnic School, and even those of the Central School, have to pass. When admitted, the pupils enjoy much greater liberty than in the last-named schools, and have not to go through so frequent examinations.

Lastly, the pupils are obliged to attend only those courses which relate to the profession they have chosen. At the Zürich school the discipline is nearly the same as in our schools, but, as in Germany, the pupils are not compelled to follow any courses but those of their specialty.

The question may fairly be asked whether the severe examinations imposed on the pupils of the Central School before their admission and during the studies are really useful. We are fully convinced that they are beneficial, and are persuaded that sooner or later they will be also imposed in the German schools as they have already been at Zürich.

In some of the German schools and at Zürich, the professors are occupied a great many hours. In France, on the contrary, they give only a small number of lessons, so that they have time for practical studies. Although the discoveries which a theoretical professor may make in pure science greatly contribute to the dignity of his teaching, the factories, machines and works of art which a professor of the applied sciences has produced, have an influence equally great on his pupils. The confidence of the auditory is proportioned to the estimate in which the professor is held by public opinion, and this is always measured by the service rendered or the impulse given to the ideas of the time. The Central School has always been most careful to choose professors whose authority doubles the force of their words and the fruit of their lessons.

The Central School is distinguished from the other French professional schools and from the Polytechnic, inasmuch as it admits pupils of all countries on the same footing as the natives of France. It is truly an international and cosmopolitan establishment. The number of foreign pupils has been and still is considerable.

In opening its door to foreign pupils, who have amounted to about one-third the number of the French, the school not only consulted its own prosperity, but also adopted a patriotic course beneficial to France. No one can fail to see the advantage that must accrue to our country from the bonds of union formed between these young foreigners and their French companions during the three years' study, an intimacy often ripening into lifelong friendship.

Historical Retrospect and Conclusion.

The success of the Central School is a very remarkable proof of the power of private enterprise. In a few years, notwithstanding the terrible ravages of the cholera in 1832, the Central School had so far prospered as to rank with our most useful institutions. It is really astonishing that such important results were obtained with so small a capital, the total outlay not having exceeded 200,000 fr.

It is only fair to state that the first professors joined in the enterprise with a zeal which the State would not, perhaps, have obtained; for many years they laboured indefatigably, and were content with a very moderate salary, considering the number of hours occupied and their high professional reputation. To this zeal for the prosperity of the school, to the earnestness of their language, and to the sincerity of their affection for the pupils, were the first professors indebted for the success and durability of their work.

However, that large establishments like the Central School cannot, without inconvenience, be left in the hands of speculators, as there would always be reason to fear that the excellence of the teaching might be sacrificed to the desire of realising the greatest possible profits in the shortest possible time. For instance, that the Polytechnic School and the Schools of Law and Medicine would have been well placed in the hands of speculators? We may be allowed to doubt the fact. Now the Central School is nowise inferior to those institutions; it is the great school of industry.

AUG. PERDONNET.

In a general summary of the whole subject the Commission say:—

With regard to technical instruction properly so called, the importance of the highest order of institutions, such as the Paris Central School of Arts and Manufactures, the Polytechnic Institutes of Germany, the Schools of Ponts et Chaussées and of Mines, which admit out-door pupils, has been abundantly manifested by the different reports which have made known their internal organisation, their technical divisions, their programmes, and the tests applied to ascertain what the pupils have learned from their studies. Public notoriety and the active part taken by the pupils of the Paris Central School in the progress of our industry and in the development of public works, are proofs too evident for any doubt to remain as to the utility of such establishments, and the great diffusion of them in Germany forbids France to be content with the state of things existing within her borders.

See also the following Works.

Programme des Conditions d'Admission à l'École Impériale Centrale des Arts et Manufactures. Année 1868. Paris, Delalain. Small 8vo.

Programme des Conditions pour l'Admission des Élèves 1868. 8vo.

Programme des Cours 1re, 2^{e}, 3^{e} année. Paris, Gauthier-Villars. 1867.

Letter from M. J. Petiet (Director of the School). "À Messieurs les Anciens Élèves de l'École Centrale des Arts et Manufactures." With "Pieces Justificatives." Paris, June, 1868.

ÉCOLES D'ARTS ET MÉTIERS

(At Aix, Angers, and Châlons-sur-Marne).

See the following Works.

Prospectus. 4to.

Imperial Decree; with circular Letter from the Minister to the Prefects of the Departments. March, 1866. 4to.

Arrêté, by the Secretary of State, with further regulations. 18 Dec., 1866.

Programme des Conditions d'Admission aux Écoles Impériales d'Arts et Metiers. Paris. Delalain.

ÉCOLE D'APPLICATION DU GÉNIE MARITIME.

See the following Work.

Reglement concernant le Service Intérieur de l'École Impériale d'Application du Génie Maritime. Small folio.

ÉCOLE CENTRALE D'ARCHITECTURE, PARIS.

See the following Work.

Régime et Programme de l'Enseignement. Paris. 1865.

This appears to be a prospectus issued in anticipation of the opening of the school, which was announced for the 10th November, 1865. No mention is made of any connection with the Government.

CONSERVATOIRE DES ARTS ET MÉTIERS.

Although this is not strictly connected with Engineering, the following account, given by the French Commission, shows that it aids materially in promoting practical knowledge in many mechanical matters:

The oral teaching of the Conservatory of Arts and Trades is exclusively devoted to science applied to industry; it addresses an audience for the most part composed of apprentices, foremen, and workmen already instructed; but besides these there are also some few foreign professors and many persons who take an interest in the progress of technology. These public and gratuitous courses thus open, with a liberality truly French, to both natives and foreigners, constitute a free instruction analogous to the lectures at the Sorbonne, the College of France, and the Museum of Natural History. Its object is rather the applications of science than science itself properly so called; but it must nevertheless advance *pari passu* with the latter, and the unequal character of the audience to whom it is addressed involves a special difficulty for the professors much greater than may be generally supposed.

To expound the principles of descriptive geometry and of mechanics, as well as their applications, without having recourse to scientific formulæ of an order too high for the generality of the hearers; to deduce from a few general elements and observed facts the laws of natural phenomena, and thence infer the rational processes to be followed in the practice of the arts; to render strictly scientific instruction intelligible to the average mind in a simple manner without using calculations or reasoning too hard to comprehend;—these are difficulties of which scientific adepts who have never made the experiment can have little conception. This, however, is a condition that must be satisfied under pain of falling into a mode of teaching without fixed principles, or into one, equally injudicious, of too dogmatical expositions, bristling with calculations and formulæ which would drive away hearers uprepared to receive them or already engaged in the actual practice of their trades. Such of the professors as have been attached to the Polytechnic School, to the schools of application for artillery and engineering to the Central School, &c., where the professors can join to the simplest methods all the scientific resources of the highest order, have unanimously acknowledged, from their own experience, how much more difficult it is to teach in a clear, simple, and rigorous manner at the Conservatory than in the establishments above mentioned.

To this difficulty, which certain courses cannot altogether escape, must be added, at the Conservatory, that of keeping the instruction on a level with all the improvements constantly being made in science and its applications, as well in France as abroad. In this respect, and owing to this necessity, the lectures here given are among the most progressive in the world; this fact is so well known that they are attended by a great number of young foreigners of all classes, and especially by young men who are preparing to become professors.

SCHOOLS AT MULHAUSEN.

See the following Works.

Notice sur les École de Mulhouse; redigée d'après des Notes réunies par le Comité d'Utilité publique de la Société industrielle. Paris, Lacroix, 1867. 8vo.

This work contains accounts of the following schools:

École primaire communale. Cours populaires, ou classes d'adultes.
École professionelle.
Collége communal.
École préparatoire à l'enseignement des Sciences et des Lettres (École supérieure des Sciences appliquées).
École Israelite d'Arts et Métiers.
École de Tissage mécanique.
École de Filature.
École supérieure de Commerce.
École de dessin.
Prospectus of the École Professionelle de Mulhouse. 4to.

ÉCOLE DES MINEURS DE ST. ÉTIENNE.

See the following Works.

Prospectus. 8vo.
Ditto. 4to., 1866.

Reference may also be made to the following:—

WORKS ON GENERAL SUBJECTS CONNECTED WITH FRENCH TECHNICAL EDUCATION.

De l'organisation de l'enseignement industriel et de l'enseignement professionel. Par M. le Général Morin, Directeur, et M. Tresca, sous Directeur, du Conservatoire Impérial des Arts et Metiers. Paris. Chaix, 1862.

Rapport sur l'organisation de l'enseignement industriel en Allemagne et en Suisse. Juin, 1864. Paris, Imprimerie Impériale, 1865.

(A translation of this has been presented to the English Parliament and published as a Blue Book. 1869, No. 22,925).

Commission de l'enseignement Technique, Rapport et Notes. Paris, Imprimerie Impériale, 1865. (This is also published in an English Blue Book with the evidence. 1868, Nos. 20,605 and 20,605 a).

Programme d'examen du Baccalaureat à Sciences complet. Paris, Delalain.

All these are in the Library of the Institution.

BELGIUM.

gard to Engineering education in Belgium, an important randum has been sent by Mr. Barlet, on behalf of the tor-General in the office of the Minister of Public Works, at ls. The following is a translation:

Government has organized the professional education in m in such manner as to form a general system of instruc- llowing the young men destined to become Engineers to e successively the elementary and the special knowledge they require. With this object the Royal Schools (Athénées) ted in the different provinces of the kingdom comprise each essional section, the principal object of which is the teaching sciences, and in which the studies are organized in such ner that, on leaving these establishments, the pupils are in a n to undergo the examination required for admission to one three Special Schools which the Government possess in the y, namely—

"École du Génie Civil," at Ghent; the Military School, ssels; the School of Mines, at Liege.

programme of the examination for admission is the same se three Schools, and will be found at page 105 of the pub- programme.

École du Génie Civil.

School is annexed to the University of Ghent, which is one two Universities established in Belgium at the cost of ate.

omprises various sections, which are attended respectively by pils who have in view the obtaining of one of the following as:—

That of *Honorary Engineer* of Ponts et Chaussées.
hat of *Honorary Conductor* of Ponts et Chaussées.
hat of *Civil Engineer.*
hat of *Engineer-Architect.*

hool of Arts and Manufactures is also annexed to the sity of Ghent; the students who have passed the examina- f this school obtain the diploma of *Industrial-Engineer.*

Organization of the Section of the École du Génie Civil, designed for the training of Engineers of Ponts et Chaussées.

This section is divided into two Schools, which the pupils attend successively, namely, the Preparatory and the Special Schools.

The *Preparatory School*, which is analogous to the Polytechnic School of France, embraces under its code of instruction all the theoretical knowledge necessary for the preparation to the special studies. The programme will be found at pages 39 to 59 of the work named at the end of these notes.

At the end of each year the students undergo an examination on the whole course passed through in that year.

The *Special School* comprises three years' study; the instruction given therein is both theoretical and practical. The theoretical instruction is given at the School during the winter months; the programme will be found in the work named at the end of these notes, pages 61 to 78.

An examination is held at the end of each year.

A special course of Railways was instituted at the Special School by a ministerial decree of the 20 Sept., 1867; the programme is given in an addendum to the published programme of the School, (bound therewith, in the library of the institution): it is included in the examinations, on leaving the School.

The summer months of the three years are appropriated to the practical instruction of the students. With this view they are sent to the constructive works carried on by the State, and placed under the direction of the Engineers of Ponts et Chaussées. They have to prepare every year a report on the works where they are stationed, and the merit of this work is taken account of in the examinations which they successively undergo for their final diploma.

This section of the School is almost exclusively attended by young men destined to enter the service of Government in the quality of Engineer, either in the Corps of Ponts et Chaussées, or in the administration of the railways of the State.

Organization of the Section of the École du Génie Civil designed for the training of Conductors of Ponts et Chuassées.

This section of the School comprises only two years of study, one in the Preparatory, and one in the Special School.

During the first year the students receive merely theoretical instruction; the programme will be found in the printed Syllabus, pages 79 and 80.

The summer of the second year is devoted to teaching certain special courses (see Programme, pp. 81, 82), and during this time the pupils are sent to the constructive works of the State to acquire practical experience.

An examination is required for entrance into this section of the School (see Programme, p. 121), and after each year of study the pupil-conductors must undergo an examinination on the subjects learned during the year.

Organization of the Studies for obtaining the Diploma of Civil Engineer.

Young men who wish to obtain the diploma of Civil Engineer are admitted into the section of the Special School, which has been instituted to that effect, after having passed an examination, of which the substance will be found on page 125 of the Programme.

Generally, before going through this examination, they follow for a certain time the course of the Preparatory School of the section of Ponts et Chaussées, in order to gain the knowledge required for the admission-examination.

The duration of the studies for this section of the School is two years; during the winter of which the students are taught the subjects mentioned in pages 81 to 84, which form the object of the two examinations they successively undergo.

During the summer of each year they are authorized to follow the constructive works of the State, along with the student-engineers and conductors of the Ponts et Chaussées.

This section of the School is attended, for the most part by young foreigners.

Sketch of the Organization of the Studies for obtaining the Diploma of Engineer-Architect.

This section of the School comprises two years of studies at the Special School; but as the programme of the examination for admission required from the students (p. 129 of the Syllabus) contains matters which are not taught in the establishment of middle class education of the country, they are obliged to follow, during one year at least, the course of the Preparatory School of the section of Ponts et Chaussées.

The subjects taught during the winter of the two years which the student Engineer-Architects pass at the Special School will be found at pages 87 to 91 of the published programme; these subjects form part of the two examinations required of the students for obtaining the final diploma.

School of Arts and Manufactures.

This School comprises three years of studies, one at the Preparatory School, where the instruction is exclusively theoretical, and two at the Special School, where the theoretical instruction is given during the winter months; the summer being devoted to visiting the industrial establishments of the country, and to the preparation of designs for industrial constructions, which the pupils elaborate under the direction of their professors.

Besides the test for admission to the Preparatory School of Arts and Manufactures (see page 137 of the Programme), an examination is required at the end of each year of study, having reference to the subjects taught during the year, and which are indicated at pages 93, 95 and 101.

NOTE.—The published Programme or Syllabus referred to in the foregoing notes, and which contains all the subjects of the various courses and examinations, set out in very great detail, will be found in the library of the Institution, and is entitled "Ecoles préparatoires et spéciales du Génie Civil et des Arts et Manufactures annexées à l'Université de Gand. Dispositions organiques et réglementaires. Programmes généraux et programmes détailles a l'enseignement. Bruxelles, Imprimerie de Deltombe, 1862."

The organization of the School of Mines, of Arts and Manufactures, and of Mechanicians, at Liege, is based on the same principles. The developments of this organization will be found in the book sent.

This also is in the library of the Institution, and is entitled "Ecoles Spéciales des Arts et Manufactures et des Mines, annexées à l'Université de Liège. Dispositions, organiques et réglementaires. Programmes généraux et programmes détaillées. Bruxelles, Imprimerie de Deltombe. 1864."

In addition to the Schools established at Liege and at Ghent, by the Government, for the training of Engineers destined for the public administration and private industry, there exists at Mons a school destined to form Engineers for the working of coal, so important in that neighbourhood, and for the other branches of industry.

This School receives a subsidy from the city of Mons, of some thousands of francs, and the remainder of the expense is supported half by the Government and half by the province.

The courses and programmes of this School are contained in the *brochure* sent herewith. (This is in the Institution library, and is entitled "Ecole provinciale d'Industrie et des Mines du Hainaut;

établie sous la direction de l'administration provinciale, Rue des Ursulines, à Mons. Programme des Cours. Mons, de l'Imprimerie de Monjot. 1863.)

The courses are aided by information drawn from books of various kinds, selected and completed by the professor.

At the end of the third year of study, only those students are allowed to compete who have satisfied all the tests of examination and design which have been imposed on them during the three years.

The final competition consists in the study either of the manufacture of some chemical product, or of the working of a manufactory or a mine, or of some constructive work, of which the pupils must furnish all the designs and indicate all the conditions, both theoretical and practical.

If the design is approved, the student is admitted to the public examination, and receives a certificate of capacity. This, however, is only a simple recommendation, and gives no right to any position.

Another copy of the Syllabus of the Ghent Schools has also been received from M. Charles Andries, Engineer of Ponts et Chaussées, and Inspector of the Studies at the said Schools. He adds, in his covering letter, the following remarks:

"The instruction is both theoretical and practical; the latter is not obtained, as in England, by a permanent apprenticeship with an engineer.

"I may add that in Belgium the law does not forbid the title of engineer being assumed without having obtained a diploma."

HOLLAND.

In reference to this country copious information has been furnished (through Mr. Campbell, of the Royal Library at the Hague) in a document drawn specially for the Institution by Dr. T. Bosscha, Government Inspector of Instruction, and of which the following is a translation :

I. The present system of education for engineers in the Netherlands was established by the law of 2nd May, 1863 (Staatsblad, No. 50).

Arts. 39-43 of this law (*vide* Appendix, No. 1) treat of the Polytechnic School, or Government School for the Engineering Sciences.

Arts. 58-67 of the examinations for obtaining a diploma as engineer.

Arts. 15-22, 26-31, 55-58, on the Higher Burgher Schools, bear, too, immediate reference to the education of engineers, as the preparatory studies of the pupils of the Polytechnic School are carried on at the Higher Burgher Schools.

The relative position of the director, professors, and students at the Polytechnic School was fixed by a royal decree, 30th June, 1864 (Staatsblad, No. 81; *vide* Appendix, No. 2).

That of the director, masters, and pupils of the Government Burgher Schools by royal decree, 30th August, 1864 (*vide* Appendix, No. 3).

In the Netherlands any one who pleases is perfectly at liberty to exercise the profession of engineer, architect, mechanical engineer, or engineer for the mines. Anybody, too, who chooses may style himself engineer, architect, &c.; but no *Government diploma* conferring such title is granted except to those who have passed the regular examinations required by law (*vide* Query III.).

All engineers in the Government service, for the Ponts et Chaussées and the mines in India, must be duly qualified by the above-mentioned diploma.

II. The engineering sciences (exclusive of military engineering) are only taught at one school in the Netherlands, viz., the Polytechnic School at Delft, a Government establishment, and maintained solely at the Government expense.

According to the last budget the annual expenses are—

Professors and Masters	70,250fl.
Buildings, instruments, library, &c.	24,000
	94,250

The higher Burgher Schools, giving a preparatory course of study or the Polytechnic School, are either Government or Municipal Schools.

There are Government Schools at Tilburg, Bois-le-Duc, Helmond, Zalt-Bommel, Gonda, Alkmaar, Middleburg, Zwolle, Leeuwarden, Groningen, Sappemeer, Warffum, Assen, Utrecht, Boermond.

Some of these schools open in September of the present year.

The sum required for these Government Schools may be estimated at 320,000 florins a year.

There are Municipal Higher Burgher Schools in the following towns:—Breda, Arnheim, Nymwegen, Zutphen, the Hague, Rotterdam, Leiden, Dordrecht, Delft, Amsterdam, Harlem, Zaandam, Goes, Sneek, Harlingen, Deventer, Enschedé, Veendam, Maestricht, Venlo.

The annual subsidies granted by Government to these schools amount to about 140,000 florins.

The Higher Burgher Schools cost the treasury thus altogether 460,000 florins per annum.

This sum must not be considered as exclusively devoted to the education of engineers. As will be seen from what follows below, the Higher Burgher Schools are intended for the general instruction of all those who are not destined for the learned professions, requiring a strictly university education.

III. It has already been remarked that no regular examination nor prescribed course of study is required for the exercise of the profession of engineer.

Those, however, who wish to obtain *a diploma* must follow a fixed course of study in order to prepare themselves for the examinations they will have to pass.

Government diplomas are given for Technology, Civil Engineer, Architect, Naval Engineer (ship-building), Mechanical Engineer, Engineer for the Mines (metallurgy).

These diplomas are granted on passing various examinations, namely:

a. A general examination (called examination A) in the different branches taught at the Higher Burgher Schools, serving to prove the candidate's proficiency in all the preparatory studies.

b. Examinations in the engineering sciences themselves, differing according to the diploma demanded by the candidate, as for

1. Technology: an examination in
   - *a*. Spherical trigonometry and the principles of analytical geometry.
   - *b*. The elements of descriptive geometry.
   - *c*. The elements of theoretical and applied mechanics and knowledge of machinery.
   - *d*. Rudiments of mechanical technology.
   - *e*. Application of physics.
   - *f*. Applied and analytical chemistry.
   - *g*. Chemical technology.
   - *h*. Architecture, as far as regards the knowledge of building materials and the construction of ordinary buildings.
   - *i*. Ordinary and ornamental drawing.

2. *Civil Engineer*. Two examinations, namely, an examination (called examination B) in
   - *a*. Higher algebra.
   - *b*. Spherical trigonometry and analytical geometry.
   - *c*. Descriptive geometry.
   - *d*. Differential and integral calculus.
   - *e*. Application of physics.
   - *f*. Analytical chemistry in relation to building materials.
   - *g*. The knowledge of building materials for architectural and hydraulic works.
   - *h*. The construction of the various parts of buildings.
   - *i*. Plain architectural and hydraulic as well as ordinary drawing.

An examination (called examination C) in
- *a*. Theoretical and applied mechanics and the knowledge of machinery.
- *b*. Hydraulic architecture, comprising—
  - 1. The construction of roads, railways, and bridges.
  - 2. Sea-dykes and embankments.
  - 3. The knowledge of rivers as means of drainage and in relation to navigation.
  - 4. The construction of canals, sluices, harbours, and maritime works.
  - 5. The hydrography of the Netherlands, the knowledge of polders and mill-drainage.
- *c*. Domestic architecture, comprising—
  - 1. The construction of plain buildings.
  - 2. The principles of ornamental architecture.

d. Topographical, ornamental, and ordinary drawing, as well as the drawing of objects required in hydraulic works.
e. The drawing up of plans and estimates.
f. The elements of geodesy and practical levelling and surveying.
g. Administrative law, relating to engineering and public works.

3. *Architect.* Two examinations; the first of which (called examination B) is the same as examination B for civil engineers, and the second (termed examination C) comprising—

a. The branches of study *a—e* of examination C for civil engineers.
b. Plain and ornamental architecture, in all their bearings, and comprehending
c. Hydraulic architecture, as far as relates to roadways, bridges, sluices, and embankments.
d. Theoretical and practical levelling and surveying.
e. Architectural, ornamental, and ordinary drawing.
f. Administrative law, relating to public works.

4. *Naval Architects* (ship-building and engineers). Two examinations; the first (called examination B) in

a. Higher algebra.
b. Spherical trigonometry and analytical geometry.
c. Descriptive geometry.
d. Differential and integral calculus.
e. Applied physics.
f. Analytical chemistry, relating to the materials for shipbuilding.
g. Knowledge of the materials employed in ship-building.
h. The rudiments of naval and ordinary drawing.

The second examination (called examination C) in

a. Theoretical and applied mechanics, and the knowledge of machinery.
b. Drawing of machinery.
c. Naval architecture and designing of ships.
d. Hydraulic architecture and drawings relating to works connected with navigation.

5. *Mechanical Engineer.* Two examinations; the first (called examination B) in

a. Higher algebra.
b. Spherical trigonometry and analytical geometry.
c. Descriptive geometry.
d. Differential and integral calculus.

e. Application of physics.
f. Analytical chemistry, relating to materials for machinery.

The second examination (called examination C) in

a. Theoretical and applied mechanics and the knowledge of machinery.
b. Mechanical technology and the construction of machines.
c. Architecture, as far as relates to the knowledge of materials and the construction of ordinary buildings.
d. Ordinary drawing and designing of machinery.
e. Administrative laws relating to manufactories and machines.

6. *Engineer for the Mines.* Two examinations; the first (called examination B) in

a. Higher algebra.
b. Spherical trigonometry and analytical geometry.
c. Descriptive geometry.
d. Differential and integral calculus.
e. Application of natural science—physics.
f. Mineralogy.

The second examination (called examination C) in

a. Theoretical and applied mechanics and the knowledge of machinery.
b. Architecture, as far as relates to the knowledge of materials and the construction of ordinary buildings.
c. Theoretical and practical surveying and levelling.
d. Geology and its applications.
e. Working of mines.
f. Testing of ore and docimacy.
g. Metallurgy.
h. Drawing of machinery.
i. Administrative laws relating to mining.

IV. On referring to No. II. it will be seen that there is but one Polytechnic School in the Netherlands. No list of establishments for engineering education is to be given, unless comprising the *preparatory schools*, already mentioned *sub* No. II., and which are again referred to in the appendix to this paper.[1]

According to the system of examinations, described above in No. III., the instruction at the Polytechnic School is subdivided into a biennial course of studies for each examination, except for technology, which requires a three years' term.

Hence a three years' term of study is required for technology and four years for the other engineers.

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[1] *Vide* Additional Note on the Higher Burgher Schools.

The course of studies for the different branches is given in detail in the programme of the lessons (Appendix, No. 4). (B 1 refers to students in their first year; B 2 to students of the second year; C 1 to those of the third; and C 2 to those of the fourth year.)

The students at the Polytechnic School are quite free and on the same footing as at the universities. The professors give their lectures, and by letting the students respond from time to time they are enabled to see if they have made themselves perfectly understood. In the laboratory for chemistry and natural sciences the students practise analytical chemistry and experimental philosophy. An excellently-arranged workshop affords them the opportunity of learning to handle tools, to use the turning-lathe, &c., and to construct models of machines. The professors of mechanical technology and the construction of machinery accompany the students on visits to the principal manufactories and works; the professor of geodesy practises surveying with the students in the environs of the town; the professors of architecture and mineralogy make occasionally scientific excursions into foreign countries accompanied by some of the students.

Officially no text-books are indicated. Every professor has liberty to follow his own plan and method of instruction. In the Government Reports on Higher, Secondary, and Primary Instruction, submitted to the States-General in 1864-5 and 1865-6, some details are given concerning the extent of each course of study, and mention is made of some of the works followed by the professors, as

"Traité de Géometrie descriptive," by Leroy.
"Analytische Géometrie," by O. Fort.
"Leçons de Géometrie analytique," by Lefebure de Foucy.
"Leçons de Géometrie analytique," by Briot and Bouquet.
"Lobatto, Leerboek der regtlynige und Sphaerische trigonometrie."
"Cours d'analyse," by Sturm.
"Traité de Mécanique rationnelle," by Delaunay.
"Traité de la Chaleur," by Piclet.
"Cursus vas Waterbouerkunde" (hydraulic architecture), by Storm Buysing.
"Ornamenten-Schule," by Bötticher.
"Tectonik der Hellenen," by Bötticher.

VI. On the subject of diplomas all that was necessary has been stated *sub* Nos. I. and III.

VII. Pupilage is not practised in the Netherlands.

VIII. Reports: Government Reports on the state of Higher, Secondary, and Primary Instruction in the Netherlands in 1864-5 and 1865-6.

The Polytechnic and Higher Burgher Schools were established in 1864, therefore nothing is to be found about them in Government Reports of earlier date. The Report for 1866-7 has not been published at the present date.

Information regarding the development of secondary instruction in the Netherlands since 1863 is to be found in the following paper: "Overzicht vas het Middelbaar Onderwijs hij het einde vas 1867, door Dr. D. J. Steyn Parvé," from the "Economist," March and April, 1868, and subjoined as Appendix No. 5.

Additional Note on the Higher Burgher Schools.

Higher Burgher Schools are establishments at which boys, after a course of primary instruction, may continue their studies until fitted for every-day life, or fully prepared for the special study of some profession, as engineer, the civil service in India, or cadetship in the army.

Pupils mostly begin their studies at the Higher Burgher Schools between twelve and thirteen years of age.

A complete course of studies at a Higher Burgher School comprises a term of five years, so that pupils generally leave the school at about eighteen years of age.

In some smaller towns there are Higher Burgher Schools, with only three classes, each for one year's study. These three classes are identical with the three lower classes of a school with a five years' course of study. Hence pupils of these smaller schools must attend the two higher classes of the complete school, each for one year's term, before passing the final examination.

These smaller schools serve in some measure to provide for the want of instruction experienced in places that cannot afford the expense of a larger school.

The subjoined syllabus (p. 83) of the lessons at a Higher Burgher School *with five classes*, only allowing for some few immaterial deviations occasioned by local circumstances, is generally followed.

The programmes of the schools are drawn up every year. Examples of them are offered in Appendix No. 6, in those of three schools, from which may be seen that liberty is allowed to vary the course of study according to local exigencies.

The system of branch instruction is followed, so that no single class is under the direction of *one* master, but instructors are appointed for the different branches of study, who give lessons through all the classes.

As a general rule no master gives more than twenty—twenty-two lessons, one hour each, per week.

NUMBER OF LESSONS IN THE WEEK.

	First Year.	Second Year.	Third Year.	Fourth Year.	Fifth Year.
Mathematics	8	8	6	4	3
Mechanics	..	..	1	2	3
Natural Sciences	..	..	2	3	3
Chemistry	..	..	2	3	4
Zoology and Botany	1	1	..	..	..
Geology and Mineralogy	..	..	1	..	..
Cosmography	..	1	1	1	1
Dutch Laws and Constitution	..	..	..	..	1
Political Economy	..	..	2	2	1
Geography	3	2	2	2	1
History	4	4	3	2	2
Commercial Science	..	..	3	2	2
Dutch Language and Literature	4	3	2	2	2
French ,, ,,	5	4	2	2	2
English ,, ,,	..	4	2	2	2
German ,, ,,	3	3	2	2	2
Caligraphy	1	..	..	..	..
Ordinary and Rectilinear Drawing	5	4	4	4	4
Gymnastics and Drilling	3	3	3	3	3
Practical Chemistry in laboratory	..	..	..	2	2
Experimental Philosophy	..	..	..	..	1

Pupils who have followed the whole course of study at the school are considered far enough advanced to pass the final examination, which is held annually under a board of examiners appointed by Government in every province of the kingdom.

This examination is subdivided into a written examination, which takes place at the different schools, and an oral examination by the board of examiners. The papers for the written examination are identical for the pupils of all the schools. They are submitted by the members of the examining commission for the approval of the Government inspectors. The written answers of the pupils are submitted to the board of examiners.

In 1868 provisional regulations were made for this examination, and the board of examiners was requested to state their opinion on the subject to the Minister of the Interior.

These regulations will be found in Appendix No. 7.

The Appendices sent with this document, and which are preserved in the Library of the Institution, are the following:

No. 1. Staatsblad van het Koningrijk der Nederlanden, No. 50.
No. 2. Reglement voor de Polytechnische School.
No. 3. Staatsblad, &c., No. 91.

No. 4. Polytechnische School. Programma der Lessen,]

No. 5. Overzicht van het middelbaar onderwijs.

No. 6. Programma van de Rijks hoogere Burgerschool te mond. 1867-8, and two other documents referring to th establishment.

No. 7. Voorschrift betrekkelijk het eindexamen der] Burgerscholen.

SWEDEN.

Sandberg has communicated the following translation[1] of a
ort on Technical Education in Sweden" by M. Dahlander,
ssor at the Chalmers Technical School, Gottenburg:

Report on Technical Instruction in Sweden.

though technical instruction in Sweden has not yet fully
ed the high situation it occupies in Germany, it has, notwith-
ling, largely contributed to the progress of our industry.
ssessing but small resources of capital, and working forces, it
ll more necessary for Sweden, than for most other countries, to
y elevating the intelligence of the industrial classes, to com-
ite what is wanting in outer expedients. This truth has also
appreciated by the Government as well as the Parliament,
er of which have denied the required sums for technical
iction. The contributions left by the State to the schools
ng to promote industry—mining, agriculture, and naviga-
-are in our circumstances by no means inconsiderable, and
be estimated as follows:

		£.
For Technical Schools . . .	at	13,500
„ Agricultural Schools . . .	„	10,000
„ Navigation Schools . . .	„	2,500

l instruction is given free at the schools of the Swedish State.
concerns even the technical instruction. The Technical
ls in Sweden may be divided into four different kinds:

. Those intended for the Higher General Technical Instruc-

d. The Technical Elementary Schools.
l. The Special Schools.
ı. Institutions intended for instruction on evenings and
ays to persons of the industrial classes.

e will, in few words, give an account of these different schools.

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[1] A few verbal corrections have been made in this Paper.—Ed.

I. *Higher Technical Schools.*

Marieberg.

There is in Sweden a military organised corps, corresponding to the "Corps des Ponts et Chaussées" of France. These Engineers receive their technical education at the Higher Military Academy, Marieberg, near Stockholm, where a special teacher is employed in Civil Engineering; and, besides, instruction is given in higher mathematics, descriptive geometry, natural philosophy, chemistry, mechanics, astronomy, topography, &c. This Institution some twenty or thirty years ago was of great benefit, and most of the engineers now employed at the building of railways, canals, harbours, &c., of the State have pursued their learning there. Now-a-days it is of comparatively less importance.

The Royal Technological Institute.

The higher technical instruction in Sweden is chiefly imparted at the Technological Institute in Stockholm. Already in the year 1798 there was founded a Mechanical School, afterwards transformed into a higher Technical Establishment. Since that time it has undergone several changes, and, in its present form, constitutes an establishment well enough resembling the Polytechnic Institution of Germany, though on a considerably smaller scale. Its latest statutes are of the year 1867, when the Mining School was to be removed to Stockholm, which removal, however, is not yet completely performed. According to the new schemes, the Institute is parted into two divisions: an inferior class, in which the instruction is common to all the students, and including all subjects regarded as preparatory for the particular technical instruction, and a higher class with the following special schools:

1. For Mechanical Engineering.
2. " Chemical Technology.
3. " Mining.
4. " Civil Engineering.

In the inferior class the course is one year; in the higher, two years. It commences the 8th September, and ends the 10th of June. For the students belonging to the last course of the School of Mines, the time between the first of May and 8th of September (except one month's vacation) is devoted to practical exercises in mines and iron works, &c.

The students are partly those who follow the instruction required for receiving diplomas, partly those who follow the instruction in one or several subjects after their own choice. The lower divisions require knowledge in arithmetic, algebra, geometry, natural philosophy, history, geography, and grammar.

The instruction is given without fee, but fines are paid for every lesson neglected by the students.

The plan of instruction for this year is as follows:

Subjects of Instruction.	No. of Hours per Week.	
THE INFERIOR CLASS.		
Mathematics and Theoretical Mechanics	..	9
Natural Philosophy	..	4½
Chemistry	..	4½
Descriptive Geometry and Drawing	..	10
Practical work in the workshop	..	5
THE HIGHER CLASS.		
The Special School for Mechanical Engineering.	First Year.	Second Year.
Mathematics and Theoretical Mechanics	13	
Practical Mechanics and Drawing	6	17½
Mechanical Technology	..	3
Applied Physics	..	5½
Geognosy	4½	
Architecture	9½	
Civil Engineering	..	7
The Special School for Civil Engineering.		
Mathematics and Theoretical Mechanics	13	
Practical Mechanics and Drawing	6	12½
Applied Physics	..	5½
Chemical Laboratory	8	
Geognosy	4½	
Architecture	9½	
Civil Engineering	..	12
The Special School for Chemical Technology and Mining.		
Chemical Technology	..	4½
Chemical Laboratory	8	14
Geognosy	4½	
Architecture	9½	
Practical Mechanics and Drawing	7	
Applied Physics	..	5½
This course of instruction will be considerably changed when the Mining School has been completely removed to Stockholm.		

At present the number of students is 123. The budget amounts to £4,000.

The superintendence of the Institute belongs to a Board of Directors, consisting of four members appointed by the Government, and two by the Society of Iron Manufacturers. The actual direction belongs to an Administrator appointed by the Government, and who is also a member of the Board. A Commission, consisting of all the instructors, submit proposals to the Board of Directors on all questions concerning the instruction. The instructors are seven professors appointed by the Government, and, in addition, eight instructors appointed by the Directors.

The Technological Institute in Stockholm includes a magnificent building, with laboratories, workshop, apartments for lectures and drawing, and provided with rich collections.

Chalmers Institute.

There is in the important commercial town of Gottenburg a Technical Institution in two divisions, one of which constitutes a Technical High School. This Institution was founded in the year 1829 by means of a donation by an Englishman, William Chalmers, who had come over to Sweden and made his fortune, and died in Gottenburg. It was afterwards undertaken by the State. As just mentioned, the establishment consists of two divisions—one inferior and one higher. The inferior division, however, is not here, as most commonly, a preparatory school for the higher one, but chiefly intended for imparting an elementary technical instruction to young men wishing to become qualified for the inferior places in the service of industry. In this inferior division instruction is given especially in practical iron and wood work, mechanical and freehand drawing, moulding in clay and wax, and in the rudiments of mathematics and mechanics. The higher division is intended to form constructors, foremen, managers of manufactories, technical chemists, and architects. Instruction is there given in pure and applied mathematics, including analytical geometry, differential and integral calculus, theoretical and practical mechanics, physics, chemistry, chemical technology, geognosy, architecture, civil engineering, mechanical and freehand drawing, moulding and practical employment in the workshop. Each pupil is at liberty to partake of the instruction in whichever subject he may choose. But for receiving certificates he must pass a final examination in the subjects belonging to either the mechanical, chemical, or building branches. This arrangement has shown very good results.

The Chalmers Institute is now being removed into a large new building consisting of three houses, one of which contains the workshops, and another the laboratory. The number of teachers is 10, the pupils about 110. Several of these are from Norway, there being no Technical School in that country. The budget of the establishment amounts to about £2,000.

II. *The Technical Elementary Schools.*

Technical Schools are to be found in four of the smaller towns of Sweden, viz., Nonköping, Malmo, Orebro, and Boris, at which instruction is given in the elementary knowledge needed for persons who devote themselves to the industrial trades. The subjects of instruction are—elementary mathematics, mechanical and freehand drawing, elementary mechanics, mechanical technology, practical work in iron and wood, physics, chemistry, mineralogy and geology, botany and zoology, languages, and book-keeping.

The course of instruction is calculated to last three years. The number of pupils is altogether about 170. The budget is for all the schools together nearly £2,700.

III. *The Special Schools.*

In Sweden are to be found only a few schools intended to impart instruction in the special industrial trades. The higher mining school that has hitherto existed at Fahlun is now being removed to the Technological Institute in Stockholm, with which it is to be joined in the manner before mentioned. Another mining school, though with a more elementary direction, exists in Fitspstad. This school is maintained by an association of mine proprietors and manufacturers in Sweden for the benefit of ship-building. There was many years ago a royal school of naval architecture in Carlskrona, the chief harbour for the ships of war of Sweden, but this school is now to be removed to Gottenburg. Finally, there is a newly-erected weaving school in Boras, though yet of small importance.

IV. *Technical Evening and Sunday Schools.*

In several towns of Sweden there are schools where instruction is given on evenings and Sundays to persons who have already entered into the service of industry. These schools, save the one at the capital and one in the manufacturing town of Eskilstuna, have no subsidies from the State. Several of them are very well arranged, and of great use. Particularly so is the school existing in Stockholm; it is of very great importance, and may rival the best establishments of this kind in other countries. It is contained in a large building newly erected for the purpose. The subjects of instruction are:

Mathematics, mechanical and freehand drawing, architecture, engraving, moulding, painting, Swedish and German languages, and book-keeping. The season lasts from the 1st of October to the 30th of April. Pupils of both sexes are admitted, and chiefly consist of workmen who have already any of the industrial trades. The number of pupils is at present 1,354, 859 of which are males, and 495 females.

The budget of the school amounts to about £4,000.

G. R. Dahlander.

RUSSIA.

THE information as to the practice in this country, is conveyed in a series of notes compiled by General Augustinovich, of Odessa, and sent through Sir Charles Hartley.

The General says in the covering letter:

"According to our laws, none are permitted to practise architecture but those who have received a diploma of examination in Russia. As to Engineers, there is no law that I know of; and on the railways now under construction there are a number of foreign engineers in the service of private companies: there are, however, over these companies Inspectors, who are Engineers of the Crown."

NOTES.

I. & II. *On the General System adopted in Russia for the Education of Engineers, and the Examinations which they have to pass before entering the Profession.*

There exist in Russia five corps of Engineers of the State, viz.—

1. Military Engineers.
2. Naval Engineers.
3. Engineers of Maritime Constructions.
4. Engineers of Ways of Communication.
5. Engineers of Mines.

These Engineers receive their education in the following establishments:

1. At the School of the Academy of Military Engineers.
2. At the School of the Engineers and Artillerists of the Marine.
3. At the Institute of the Engineers of Ways of Communication.
4. At the Institute of Mines.

All these establishments belong to the State; there are no private ones of the kind in Russia.

In 1867 the Institute of Engineers of Ways of Communication, and in 1866 the Institute of Mines, were completely reorganized, so as to furnish Engineers, not only for the State, but also for private industry. Also, none of the students of these Institutions are now iged to serve six years to the State, as was the case before 1864 : the students educated at the expense of the Government. he students of the Institute of Ways of Communication have hanged their name to that of Civil Engineers, and the Corps of Engineers of Ways of Communication is now completed by these latter; the students of the Institute of Mines have retained the name of Engineers of Mines.

The encyclopædical course of the Gymnasium is adopted as the basis of education for the Civil and Mining Engineers; no one can be admitted into the technical institutions for these till he has finished his education at the Gymnasium, or in an equivalent establishment. Youths educated at home may undergo examination in one of the gymnasia of the Empire, on the full course of these establishments, excepting the Latin and Greek languages.

The Institute of Mines admits, further, external students, but these latter cannot receive their diplomas of Engineer before having gone through the examinations of the Gymnasia. Further, every student of the Institutes of Ways of Communication and of Mines is required also to pass, before the professors of those Institutions, an examination in mathematics and physics, in order to furnish the means of testing the knowledge acquired. The pupils of the Universities and of equivalent establishments are excused from these testing examinations.

The students remain ordinarily at the Institute for five years, corresponding to five classes of the Institute; but this term may be diminished by passing the examinations of two or three classes at a time. The minimum of the term passed by the students of the Institute of Ways of Communication is two years. The Institute of Mines admits to the final examinations any person having a diplóma of the Gymnasium, and who can certify that he has been employed for at least a year in any manufactory.

In the months of April and May the pupils are obliged annually to undergo examinations in the course gone through during the year, in order to pass to the following class. The final examinations at the Institute of Ways of Communication have reference only to the courses of construction, architecture, mechanics, and geodesy. The pupils must further present four complete designs; two in the art of construction, one in architecture, and one mechanical.

III. *On the Interest shown, and the Nature of the Assistanc rendered by Government in the Education of Engineers.*

The establishments above mentioned belong to the State, a are supported by Government, who control them through the Minis of Public Works and the Minister of Finance. The annual bud of the Institute of Ways of Communication amounts to 99,426 roubles (£15,535), which is distributed thus—

Roubles.	
65,100	for the management, the professors, and the staff of the establishment.
6,000	for the encouragement of needy and industrious students.
5,200	for laboratory, furniture, drawings, practical operations of the students, &c.
4,000	for the museum and library of the Institute.
19,126	for general expenses, warming, lighting, and other expenses of maintaining the Institute.
99,426	

The number of pupils at the Institute is not limited; at the present time (Sept. 1868) there are 209, of whom 20 receive each an allowance of 300 roubles per annum, carried to the budget of the Institute; and 21 are supported by various departments of Government, other than the Minister of Public Works.

The budget of the Institute of Mines is higher, and amounts to 108,270 roubles (£16,917), thus appropriated—

Roubles.	
61,200	direction, professors and staff.
9,000	encouragement of students.
7,700	laboratory, &c.
3,000	museum and library.
21,000	general expenses.
6,000	allowed for payments to students, &c., selected to be sent for improvement into manufactories.

The number of pupils at the Institute of Mines is now 99, of whom 30 receive each an annual allowance of 300 roubles, and 18 are supported from various other departments and manufactories.

IV. *On the Course of Studies followed at the Institute of Ways of Communication, and the Institute of Mines.*

At the former, the following subjects are taught:

General notions of theology.

Law, having particular reference to constructions and ways of communication.

Political and statistical economy.

Chemistry, general and analytical.

Physics, general and technical.

Telegraphy.

Mineralogy and geognosy.

Mathematics, differential and integral calculus, and analytical geometry of two and three dimensions.

Descriptive geometry, and its application to the theory of shadows, to perspective, and to isometrical projection.

Drawing.

Topography, astronomy, and geodesy.

Statics and analytical mechanics.

Applied mechanics (kinematics, living prime movers, hydraulics and water conduits, aerodynamics), and the steam-engine.

Constructive mechanics (the theory of the strength of materials and of the stability of the parts of buildings).

The art of construction (studies of materials, works of construction and foundations, drawing and irrigation, the consolidation of lands and slopes; the embankment of rivers, and other means of preservation against inundations; sewers, bridges, roads, and railways; the improvement of navigable streams, canals, harbours, and docks).

Architecture.

The preparation of designs for mechanical and architectural objects, for bridges and other constructions.

Every student is also obliged to study one of three languages, English, French, or German.

The courses are taught at the Institute for the three first classes from the 1st September to the 1st April, and for the two last from the 15th October to the 1st April; from the 15th April to the 15th May the examinations are held for all classes; and the time from the 15th May to the 1st September is occupied by holidays and the practical occupations of the pupils. These last consist, for the 3rd class, of land-surveying and levelling, studies of velocity and volume of streams, as well as geognostical excursions. The pupils of the 4th and 5th classes are, from the 15th May to the 15th October, put at the disposition of various Engineers engaged in the construction of public works.

The library of the Institute contains 8,128 works, in 16,850 volumes.

The Museum is composed of six collections, viz., models, philosophical instruments, surveying instruments, materials of construction, minerals and crystals, tools. There is a special laboratory for chemical experiments, and another for mechanical testing.

At the Institute of Mines the following subjects are taught:

General ideas of theology.

Law, with special reference to industrial subjects.

Political and statistical economy.

Mathematics, the differential and integral calculus, and analytical geometry of two and three dimensions.

Descriptive geometry.

Drawing.
Topography and levelling.
Statics and analytical mechanics.
Applied mechanics.
The art of construction (studies of materials, of works of construction and of foundations, theory of the strength of materials, and of the stability of walls and arches, hydraulic constructions, workshops).
Architecture.
Physics, general and technical.
Chemistry, general and analytical.
Botany and zoology.
Mineralogy and crystallography.
Geology and geognosy.
Palæontology.
The working of mines.
Subterranean geometry.
Assaying.
Metallurgy.
The preparation of designs, of mechanical and architectural subjects, and of hydraulic constructions.

Every pupil is further obliged to study one of the three languages before named.

The courses are pursued at this Institute from the 15th September to the 15th April. From the 15th April to the 15th May the examinations are held, and from this latter date to the 15th September are the holidays for the two first classes, and the practical occupations for the students of the three higher classes.

These occupations consist of land-surveying and levelling, visits to mines and manufactories, and excursions for mineralogy, geognosy, and palæontology.

V. *On the Nature of the Diplomas given.*

The students of the fifth class of the Institute of Ways of Communication, after having passed their final examination, receive a diploma, giving them authority for the direction of all kinds of works of construction, with the title of Civil Engineers. These diplomas are signed by the director and the secretary of the Institute.

The diplomas of the Institute of Mines give their recipients authority to the title of Mining Engineers; they are signed by the director, the inspector, two professors, and the secretary to the council of the Institute.

VI. *On the Payments by the Pupil and the Duration of his Study.*

The pupils of the Institute of Ways of Communication pay, for the right to follow the course of the Institute, the sum of 50 roubles (£7 16*s.*) per annum; and those of the Institute of Mines 30 roubles (£4 14*s.*) per annum. Students who are poor, but industrious and promising, may be excused from this payment. Further, the sums paid by the students are only partially taken by the State exchequer, the greater portion is put at the disposal of the Institute to be distributed among the poor students.

The duration of the study is mentioned above.

NORTH GERMANY.

The following information as to engineering education in North Germany generally, is taken from a communication by M. Gustave Kirchenpauer, Civil Engineer of Hamburg, who was educated at Hanover.

In the Northern German Confederation there are at present three Polytechnic Schools: at Berlin, Hanover, and Aix-la-Chapelle—the latter very recently established. There are also schools at Carlsruhe, Stuttgart, Vienna, Prague, Munich, and Zurich.

The writer is only able to supply information as to the Berlin and Hanoverian Schools.

The course of education occupies from four to five years, and consists partly of lectures as at the universities, and partly of practice in drawing and working out problems given by the teachers. The pupils attend what lectures they may choose, and the fees paid are so moderate that Government assistance is inevitable for the support of the schools. The pupils do not lodge or board at the schools.

Particulars of the lectures, fees, &c., will be found in the programmes.

Diplomas, so far as the writer knows, are only granted at Zurich; the German schools only give certificates or attestations to the students after having passed a final examination.

Engineers who wish to enter the service of the State, have, after some years' practice, to pass an examination by the State; and after having served some years, there is another examination, the passing of which enables them to obtain the highest rank.

It is not customary in Northern Germany to serve an apprenticeship to a practising engineer, nor are any fees paid by young engineers on first entering practice; in most cases they receive salaries from the beginning; they sometimes enter as volunteers for some time, but even then they mostly receive some remuneration.

There are no laws forbidding any one to assume the title of Civil Engineer, even without any previous school education; but various legitimate titles are granted to the engineers employed in the service of the State.

PRUSSIA.

Herr Hofrath Hartwich, of Cologne, director of the Rhenish railways, has communicated some particulars in reference to engineering education in Prussia, a translation of which is subjoined.

The following remarks will aid in forming a judgment as to the education of engineers and architects in Prussia.

I. There are about six hundred master-constructors (Baumeister) employed in the actual service of the State. These officials are educated in the Royal School of Construction (Königliche Bau Akademie) at Berlin, an institution which is supported entirely at the State expense, with the help of very moderate fees. In this institution there are three directors and twenty-four professors and teachers, who also, for the most part, fill high constructive offices in the State.

The institution is provided with an admirable library of valuable works.

In order to be appointed to service in the constructive department of the State, two Government examinations must be passed: these extend to—

a. Hydraulic and sea constructions.
b. Architecture and ornamental buildings.
c. Railroad and road construction.
d. Machinery and general engineering science.

In order to be admitted to the studies and to the examinations abovementioned, the student must show that he has passed the first class of the lower gymnasium education.

After he has gone through a complete general scientific training, he must, for one year, be practically engaged with one of the constructive officers of the State.

Thus prepared, he is admitted to the studies in the Royal School of Construction.

The studies, up to the first examination, as conductor of works (Bauführer), extend over two years, and comprise all branches of scientific knowledge appertaining to engineering and architecture; particular care being bestowed on the training in construction and drawing.

After passing this examination, which takes place after a lapse at least three years from quitting the gymnasium, the student mus pass another three years in actual occupation in practically carrying out the construction of works, under the direction of master constructors; he must then devote two years more to study, after which he may undergo the second examination for State employment in construction. The appointments then follow according to seniority in passing the second examination.

Engineers, architects, and mechanicians who have become qualified in the manner above described, find multifarious employment on private railways, in municipal duty, or in industrial undertakings.

In the before-described examinations, which apply to the special functions of the constructive officials of the State, no distinction is made between engineers and architects, as the sphere of action of these officials comprises all branches of engineering and architectural work; but, nevertheless, in practice the individuals form themselves into engineers or architects, as their own inclination may determine.

II. While the Royal School of Construction in Berlin has specially for its object the education of the Government constructive officials, on the basis of a complete general scientific education, another school in Berlin, namely, the Royal Industrial Academy (Königliche Gewerbe Akademie), serves for exceptional training in technical engineering, and in the mathematical, physical, and chemical sciences technically required in the various branches of manufacture.

This also is an establishment supported at Government cost. It has a director and sixteen to eighteen professors and teachers, and is furnished with an excellent collection of models and a very good library.

A scientific preparation for the studies in this establishment is only required so far as will enable the student thoroughly to understand the instruction, and logically to carry it out into practice.

It is also required that the student shall have previously passed some time in technical employment.

For specially-qualified persons there exist State grants as well as others founded by private persons.

The course in this establishment occupies three years. The education comprises the whole range of mathematics, physics, and chemistry, mechanical and constructive drawing, and also a practical activity in the mechanical branch of the institute, particularly in the practical construction of machines.

After obtaining the certificate in the first class of this institution, *the students* have no claim to employment in Government service;

but on account of their thorough training in all the branches of knowledge affecting industry and manufactures, they are especially sought after for prominent positions in industrial undertakings of all kinds, as well as in the higher mechanical departments on railways.

Under the general superintendence and direction of the Industrial Academy, and in particular under the care of the director of the same, stand the several industrial schools, which are established in the larger provincial towns. In these schools are educated mechanicians who are qualified as foremen, &c., in manufactories, and these establishments turn out many excellent practical men of this kind.

III. In addition to the above, there is now a high-class Polytechnic School at Aix-la-Chapelle, and in the province of Hanover a similar one has come into the possession of the Prussian State; but at present it is uncertain how far students educated in these schools can claim employment in the State service.

Examination certificates, which give claim to employment, are only given to constructive officers of the State. The students of the industrial academies receive attestations of their proficiency in the first class. In addition to these, private constructors for architecture and ornamental building have been hitherto examined, and attestations of their proficiency given.

In the same manner master carpenters, masons, shipwrights, millwrights, &c., must be provided with attestations of examination. For engineers no examination is necessary.

The title Civil Engineer, in the sense in which it is used in England, is here generally unknown, and has been only used by a few individuals.

According to a recent Industrial Law of the North German Confederation, the examination for following a technical trade, as well as for private constructors, masons, carpenters, and shipwrights, is no longer imperative; every man can practise any trade, with assistants and apprentices, without his qualifications being tested by examination.

Of course, however, the State requires the examination of master constructors who are to be admitted to the service of the State.

(Signed) HARTWICH.

Cologne, 28th July, 1868.

M. Hartwich adds in a note the following observations:—

The Academy belongs to the Department of the Minister of Trade.

The annual income and expenditure amount to 30,000 thalers received from the State; 17,000 thalers from other sources; an 13,000 thalers, fees from the pupils.

Seven professors are engaged entirely on the duties of the Academy, twenty are engaged in other business, and give lectures for a certain remuneration, about 100 thalers each.

In the present year the Academy is attended by five hundred and sixty students. The large hall for drawing is fitted up with accommodation for one hundred and sixteen students; and the library, which is always open to the pupils, contains a great number of the best works in all languages.

The students who pass best in the examinations receive premiums to enable them to travel for the purpose of professional instruction, on the condition of their giving descriptions and drawings of interesting objects which they have seen.

The following publications have been received, and are preserved in the library of the institution:—

"Verzeichniss der Unterrichts-Gegenstände, der Königliche Bau-Akademie ju Berlin. Winter Halbjahr, 1867-8."

Ibid, "für das Sommer Halbjahr," 1868.

(List of the subjects of instruction in the Royal Acadamy of Construction in Berlin.)

"Vorschriften für die Ausbildung und Prüfung derjenigen, welche sich dem Baufache widmen:" with

"Vorschriften für die Königliche Bau-Akademie in Berlin."

(Regulations for the training and examination of those who purpose to devote themselves to the art of construction: with Regulations for the Royal School of Construction in Berlin.)

The above-named works give full detailed information as to the course of instruction given, and the nature and extent of the knowledge which must be possessed by the students in construction, in order to pass the examinations prescribed by the State on qualifying for Government appointments.

"Regulativ für die Organization der Königlichen Gewerbe-Akademie" (no date).

(Regulations for the organization of the Royal Industrial Academy.)

"Lections Plan für das Königliche Gewerbe Institut in Berlin."

"Verzeichniss der Unterrichts-Gegenstande der Königlichen Gewerbe Akademie in Berlin."

These are programmes of the lectures and subjects of instruction in the same institution for various half years, from 1865 to 1869.

"Reglement uber die Benutzung der Bibliothek des Königlichen Gewerbehauses," 1857.

(Regulations for the use of the library of the same institution.)

The following observations are by an eminent and experienced Engineer, who does not wish his name to appear:

1. General Remarks.

In England, France, and almost everywhere, Architecture and Engineering are considered to be two independent branches, in regard to study as well as practice; each branch claiming the full exertion of those who devote themselves to it. It is only Prussia which offers a remarkable exception, requiring by Government regulations that all those who present themselves for examination and for employment in public service should fully embrace both branches.

This peculiar principle has often been contested. After the war of 1866, when several States wherein Architecture and Engineering had been separated were annexed to Prussia, it appeared for a while questionable which principle might be adopted for the future; but, after some controversy in the weekly and monthly press, the old Prussian system prevailed, and a student going up for examination is still expected to be both architect and engineer. When nominated to a public office, he will have to execute public buildings and engineering works of any kind, as may happen to be required in his official district.

Only those eminent men who have risen to superior official standing, such as the celebrated engineer, Mr. Hagen, the late eminent architect, Mr. Schinkel, and others, seem to have kept their special province in the profession.

It appears to be admitted by all independent members of the profession, even in Prussia, that the aiming at universality, in fact, frequently leads to superficiality in everything, without true understanding, and that a good deal of valuable time and exertion is to be sacrificed by the Prussian students of our profession, only for passing fairly the examination, and for being admitted to the public service.

Experience shows that young men raising themselves above the level of mediocrity are in reality either engineers or architects. They may have loaded their memory with a good many things, and may have exercised their hand to execute drawings, by which, for a while, they may appear both; but after their admittance they will, with rare exceptions, neglect and forget what they were obliged to imbibe *contre cœur*.

Experience also shows that in many cases the energy of body and mind is checked, if not broken, by overstraining during the preparation for examination; and this, of course, affects the most conscientious students.

2. Engineering Education.

Since throughout the territories of the North German Confederation the principle of free trade has been legalized, all those who do not wish to become candidates for public service are quite at liberty to educate themselves, and to become engineers how they like. They usually leave the College Gymnasium from the upper class, enter for a year or two an engineer's office as pupil or apprentice *élève*, make then two or three years' study at a polytechnical school, and after that begin practice as assistants in the service of private companies, engineers, builders, &c. This is nearly the same way as in England, except the regular study at a polytechnic school, which appears to be a preference of Germany. There is a great choice of such schools in Germany: the Bau[1]-Akademie in Berlin, the Polytechnic School in Hanover, the polytechnic schools in Dresden, Darmstadt, Carlsruhe, Stuttgart, Munich. Much frequented also by German students is the Polytechnicon at Zürich (Switzerland). In Austria, the principal are at Vienna and Prague.

The Prussian system of combining Architecture and Engineering of course rules the plan of lectures at Berlin and Hanover. Mechanical engineers find in Berlin the "Gewerbe[2] Academie," where extensive workshops offer to the students practical exercise, combined with theoretical instruction by lectures.

Those who devote themselves to the service of the State in Prussia have to pass through the following course of education.

1. General scientific education must be proved by a testimony of "maturity for university," which can be acquired by examination when leaving the upper class of a college.

2. Then follow three years' regular study at the "Bau-Akademie at Berlin," or the polytechnic school at Hanover. Part of this time may be spent at another polytechnic school.

3. One year's practice under the superintendence of State Engineers is afforded, but it is permitted to combine this with the academical years, by disposing the vacation time (several months every year) for practical purposes; so that by adding these together, and with a few months afterwards, a full year is to be made up. These three conditions being accomplished, the student may present himself for—

The First Examination.

Which comprises mathematics, including the differential calculus, all branches of engineering and architecture, theoretical and practical, geology and other auxiliary sciences, history of art, knowledge of styles, literature, perfect ability in drawing, architectural and engineering, versatility in projecting and estimating any kind of work, calculating and projecting machinery, as far as it is used for building and engineering purposes. The whole examination takes several days, by special examiners for the different studies. Each of these gives separately a certificate, viz. "distinguished," "good," "sufficient," "tolerable," "insufficient." These are brought in the full commission, which draws the result, "Admitted," or "Not admitted." In the latter case, the young man may present himself again in a year or two. If admitted, he receives the title of "Bauführer" (Conducteur), has to promise solemnly, correct, upright, and good behaviour, is declared qualified for temporary paid employment under superintendence of an official Engineer or Architect, and has "public faith" in measuring and receiving work and materials, and also in carrying accounts.

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[1] The German word 'Bau' means 'building,' which comprises Architecture and Engineering.

[2] The German word 'Gewerbe,' verbally translated, means 'trade,' and is generally used for signifying all sorts of manufacturing processes.

Now he is at liberty to choose his way of further study and practice as he likes, and when he thinks to be sufficiently prepared he may apply for—

The Second Examination.

The form for that is to send in an application for "Aufgaben" (themes, problems) connected with the declaration that he wishes to be admitted; he is permitted to name that branch of the profession (Engineer or Architect) to which he has principally devoted himself. This will be regarded at, to a certain degree,[1] but without dispensation from the other branch in general. In answer to the application, the candidate receives two themes, one in architecture, another in engineering,[2] and two years' time is left to him for coming forward with his elaboration, which requires generally a year's hard work, consisting of about fifteen to twenty large sheets of drawings (plans, sections, facades, details of any kind, machinery, &c. &c.), and accompanied by a voluminous explanatory report. The board of examiners have then to consider whether the elaboration is acceptable, and if this is affirmed, a verbal examination takes place; the main object of this being to prove the true authorship of the candidate as regards the elaboration, and to test his general knowledge, judgment, scientific standing and practical views.

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[1] This is a concession to the new, or a deviation of the old principle; indeed only a small one, but still it is a sort of acknowledgment.

[2] Themes in Architecture may be, for instance a country residence of a prince, a theatre, a grand hotel, an assembly house of parliament, and others such like. In Engineering, a harbour at a given place, a great central railway station, drainage of a certain town, waterworks, canal and river harbours, &c. &c. A programme is always prescribed.

When admitted, he receives the diploma as "Baumeister" (Master in Building), and is declared qualified for employment in public service in fixed official situation and salary. His name is inserted in the official list, and he will be promoted with regard to seniority, and as the occurrence of vacancies give occasion.

In the other States of Germany the regulations for admission are not exactly the same as in Prussia; but, with the exception of a few small States, the principle, that State-examination is indispensable, prevails everywhere.

It may be questioned whether this principle is generally a good one, and it is sometimes pretended that many mistakes occur, and even mischief is done, by these examinations; but nevertheless it is evident that if the Government of a large State will not—as the Government of the United Kingdom does—leave the greater part of public works to private enterprise, or to local self-government of magistrates or other local authorities, the German principle of training and examining is quite a necessity.

Even the best Government cannot pledge itself to fill up the numerous vacancies (occurring, perhaps, every week) with full impartiality, if there is not a legal way for candidates to acquire—according to rules which are the same for all—the acknowledgment of personal qualification, personal right, and security.

3. FACILITATION AND ENCOURAGEMENT OF STUDIES ON THE PART OF THE PRUSSIAN GOVERNMENT.

1. The obligation to prolonged studies must, of course, fall to young men of little fortune. With regard to this, the Director of the Academy is empowered, in suitable cases, on application, to respite 75 per cent. of the fees and honoraries payable at the Academy. The students benefited in this way have to sign an engagement to pay off the debt at certain terms and conditions afterwards. In extraordinary cases, great diligence, &c., the minister can remit it altogether.

2. Annually there are premiums awarded to those who distinguish themselves in the first examination. Usually the two best of them receive each a premium of 300 thalers (about £50); several others receive medals. The money premium is to be expended for a scientific journey.

3. King Frederic William IV. founded two prizes, each of 100 Frederics d'or (about £90), to be awarded at the anniversary celebrated every year at the birthday of the great architect, late Schinkel, by the "Architecten Verein," at Berlin, for the best architectural designs. There is no doubt that the described ways of encouragement have a beneficial effect. Especially the Schinkel Prize is held in high esteem and much aimed at, which probably is caused,

in great measure, by being awarded by brothers of the profession, and according to regulations which exclude, as much as possible, all partiality, personal protection, and other abuses.

4. It needs hardly to be mentioned that in connection with the Academy an extensive library is established and made accessible to the students, and that models of buildings and machinery, geological collections, and many other scientific aids are offered to their use in the most liberal way.

STATISTICAL NOTES.

Abstract from the Berlin Architect's Weekly Paper, and the "Architect's Almanac."

In Prussia were admitted, after the second examination, as 'Baumeister:'—

Year.	Number.
1859	73
1860	65
1861	71
1862	46
1863	39
1864	34
1865	40
1866	59
1867	60
1868	59
In ten years	546

Average per year 54·6.

The time between admittance as 'Baumeister' and the first fixed employment in the service of the State comes out, at the average, to about eight years.

The number of students at the Bau Academy in Berlin was, in 1868, 550 (at present about 600). The same at the Polytechnic School at Dresden is at present 377.

1868.

Number of Engineers and Architects employed in public and municipal service in the States of the North German Confederation. (Abstracted from the "Architect's Almanac.")

I. States' service:—

Prussia:—		
Central government	70	
Administration of public works, except railways	595	
State railways.	142	
		807
Saxony (kingdom):—		
Public works, except railways	52	
Academy, schools	10	
State railways	56	
		118
Carried forward		925

Brought forward		925
Brunswick:—		
Public works, except railways	38	
State railways	19	
	—	57
Oldenburg:—		
Public works, except railways	24	
State railways	5	
	—	29
Mecklenburg		28
Four Saxon Duchies		41
Five other small Principalities		29
Three Free Hanse Towns		43
In the States' service, &c.		1,152
II. Service of municipalities, magistrates, and corporations:—		
In Prussia	122	
In Saxony (kingdom)	43	
In the small States generally, coinciding with State service		165
III. Service of private Railway Companies		129
Fixed employment		1,446

Further particulars as to the Engineering and Architectural education in Prussia are given in the Report of the French Commission, English edition, page 64.

An account, also, of the excellent education established in that country for the mechanical trades, will be found in the same work, as well as in the Replies to Lord Stanley's Circular.

HANOVER.

THE following memoranda relating to the education of engineers in Hanover has been communicated by Mr. R. Crawford, Assoc. Inst. C.E.

The duration of the course laid down for students in the Department of Civil Engineering in the Polytechnic School of Hanover is five years.

The candidate's age to be at least sixteen years before joining.

Before entering the School of Civil Engineering as a pupil, an entrance examination has to be passed in the following subjects:

a. Knowledge of the German language and style, as evinced by an easy theme, to be written without errors, and in a free, natural style.

b. Facility in arithmetical calculations, including decimals.

c. Knowledge of algebraic calculations, including simple equations.

d. Plane geometry.

e. General knowledge of geography and history.

Fees.

						£.	s.	d.
The fees for the	first	year are	27	thalers	=	3	18	9
„ „	second	„	31	„	=	4	10	5
„ „	third	„	46	„	=	6	14	2
„ „	fourth	„	21	„	=	3	1	3
„ „	fifth	„	33	„	=	4	16	3

First Year's Course.

Mathematics.

Arithmetic: algebra, involution, binomial theorem, numeration, decimal and vulgar fractions, extraction of roots, rational and irrational quantities, real and imaginary quantities, equations of the second, third, and fourth order; use of logarithms.

Elements of the differential calculus: the idea of a function, of limits, of vanishing quantities, differentiation of functions of one or more variables, maxima and minima.

Geometry of plane surfaces: study of the relations of right lines, figures and circles; plane trigonometry, measurement of solids, position of straight lines with reference to planes, planes w reference to planes, material points, calculation of bodies a surfaces.

Spherical trigonometry: analytical geometry of planes (Part the elements of the analytical geometry of space, equations a point, of a straight line, of its angle with the axis, angle of t right lines, equation of a plane.

Zoology.

Botany.

Mineralogy.

Drawing: principally drawing of ornaments, partly from copie and partly from plaster casts. In the higher department als heads and figures from models.

Line drawing: construction of scales, and the frequently-occu ring curved lines in their application, drawing from copies, el mentary principles of descriptive geometry.

Second Year's Course.

Higher mathematics: differential calculus, Taylor's a MacLauren's theorems, maxima and minima of functions of number of variables, apparent indefinite values.

Integral calculus: application of the differential and integ calculus to plane geometry.

Analytical geometry of planes (Part II.), geometry of spac higher equations, calculations of interpolations, fluxions.

Descriptive geometry: orthogonal projection of points, lin and surfaces, sections, and developments; isometric projecti construction of shadows, perspective projection.

Pure physics: gravitation, atomic theory, acoustics, optics, the of heat, frictional electricity, magnetism, static electricity a electrical currents.

Applied physics: popular astronomy, mathematical and physi geography, meteorology, knowledge of weights and measures, sh review of musical instruments, lighting apparatus, optical instr ments, principles of the mechanical theory of heat, application theoretical knowledge to heating apparatus, electric telegraph.

Mechanics (first course): fundamental principles and laws mechanics, study of the motion of simple material points, equil brium, motion of solid, elastic, and fluid bodies, with application simple machinery and construction.

Third Year's Course.

General study of machinery: general economic importance machines; machines for measuring and calculating; machines fo *the reception* of motive power; machines for altering the positio and form of bodies (especially mills); agricultural machines; strength of materials (sketch of the most important results of); simple machinery—regulators, fly-wheels, breaks, centrifugal regulators; machines moved by muscular power; presses, pumps.

Higher mechanics: elasticity and strength of building materials; theory of elasticity and neutral axis; theory and calculation of the construction of roofs, wrought-iron bridges, framework, lattice, arch, and suspension bridges; calculations of iron roofs and bridges; theory of the pressure of earth, and calculations for retaining walls; general theory of the line of resistance, with application to the construction of arches; hydraulics; analytical mechanics; study of geometrical motion; mechanics of simple material points; general theory of motion; and the equilibrium of a system of material points.

Practical geometry: method of measuring surfaces and altitudes; principles of the higher geodesy, and the surveying of mines, as also the system of compensating by fluxions; the preparation of plans for agricultural and topographical surveys; plaster modelling and drawing of hills; studies from simple drawings, and practical exercises in field operations.

Building materials and construction: including masonry and carpenters' work, iron structures, excavation and materials, ornamental (decorative) works.

Fourth Year's Course.

Road and railway construction: qualities of earths, transport, performance of animals, laying out roads, staking out, levelling and cross-sectioning; construction of roads, classification of widths, solidifying the roadway, bridges, and culverts; retaining walls and other works appertaining to road making; estimating and carrying out the works; rules for repairing roads; excursions to see works in operation.

Railways: history of railways; review of motive powers; selecting and determining the line; preparing detailed plans, and the construction of railways; acquisition of land; earthworks; method of transport and plant; permanent way, materials, tools, platelaying; points and crossings; district boards; fencing; marking position for bridges; station works; works of art (exclusive of stations); constructing works; estimating them; construction of tunnels; excursions to see works in progress.

Building works: stairs and arrangements; heating and ventilating; joiners', locksmiths', and slaters' work; sketch of the history of art; study of the Greek, Roman, Old Christian, and Gothic styles of building; technical description of implements and vessels; ornamentation of the building styles of the Antique, Old Christian, and Middle Ages; modelling in gypsum and designing; designing of public and private buildings.

Geology, mineralogy, &c.: short recapitulation (summary) of mineralogy; elements of palæontology in connection with the principles of geology. (Examples and excursions.)

N.B.—It is presumed that the students have a knowledge of the natural history of animals, plants, and minerals.

Chemistry: inorganic and organic.

Fifth Year's Course.

Waterworks, &c.: wells and streams; collecting water, and conveying it on the surface of the ground; filtering and laying on water; apparatus for forcing up water; dykes and channels; works for drainage and irrigation purposes on small and large scales; navigable canals; construction of canals; construction of sluices; rivers and streams, straightening and embanking rivers and streams; maritime works, sea embankments, harbours, &c. (Excursions to inspect works.)

Bridge construction: laying foundations; approaches; bridges generally considered:

a. Bridges of stone, timber, and iron suspension bridges; swing bridges. (Excursions to examine works.)

b. Wrought-iron railway bridges; properties of the material; different systems of construction; ascertaining the movable load and the dead weight; plate, lattice, and frame girders; details of construction, arrangements for riveting and hammering; examples of calculating and estimating; practical construction, erecting in place; foundations with the aid of cast-iron, and with wrought-iron apparatus for working under water.

Building course:

a. Comprehensive studies of the works of antiquity, of the Middle Ages, and modern works; designs according to given data; working out of the designs in all their necessary details.

b. Arrangement and position of buildings, estimates, working drawings, contracts, specifications, sketches of working plans.

c. Ornamentation: designs for ornamental details in connection with architectural projects.

d. History of the art of building: German antiquities, monuments in America, Asia, Egypt, and Nubia; the art of building of the Grecians, Etruscans, Romans, Byzantines, and Mahometans; the Roman and Gothic architecture, "renaissance" and "rococco" styles with respect to sculpture and painting.

Machinery (second course): recapitulation of the principles of mechanics; experimental hydraulics, especially as an introduction to water wheels; calculation of water wheels and steam engines (the so-called coefficient theory). Calculations: calculation of pumping machinery; calculations relative to transport on ordinary roads and railways.

The following works illustrative of the Hanoverian establishments are in the library of the institution:—

"Verfassung der Polytechnischen Schule zu Hanover, October 1863." (Regulations for the establishment of the Polytechnic School in Hanover.)

"Programm der Königlichen Polytechnischen Schule zu Hanover." (Programme of the School for various years.)

"Katalog der Bibliothek der Königlichen Polytechnischen Schule zu Hanover, 1868." (Catalogue of the library of the School.)

Further information as to the Hanoverian school will be found in the French Report of 1864.

BRUNSWICK.

THERE is a State School called the "Collegium Carolinum" at Brunswick, the object of which is to prepare young men, by a scientific and technical education, for the special careers of Mechanicians, Civil Engineers, Architects, Metallurgists (for mining and salt works), Manufacturing or Dispensing Chemists, Forest Engineers, Agriculturists, officers for railways and roads, and Surveyors.

Full particulars of this establishment will be found in the Report of the French Commission of 1863, English translation, page 43.

It appears to be on the plan of the German Polytechnic Schools generally.

BADEN.

The education of engineers in the Grand Duchy of Baden is carried on in the Polytechnic School established by Government at Carlsruhe, which is pronounced by the French Commission to be "one of the most excellent establishments of the kind in all Germany:"—

This establishment is a kind of technical university, which, in addition to scientific studies of a high order, comprises in its organization several special divisions. The first of these is devoted not merely to mathematical science, as its name would seem to indicate, but also to the general scientific knowledge necessary for the other technical divisions, and which the pupils may acquire by following the particular courses relating to those sciences.

The technical divisions are:—

Engineers		requiring	2 or 2½	years.
Architects	Builders . . .	,,	2	,,
	Architects . . .	,,	4	,,
Foresters		,,	2	,,
Chemists		,,	2	,,
Constructors of machines . .		,,	2	,,
Commerce		,,	1	,,
Posts		,,	1	,,

The following information in regard to the Engineering Department of the School has been furnished by Mr. Crawford, Assoc. Inst. C.E.

The School of Civil Engineering connected with the Polytechnic School of Carlsruhe embraces all the branches of Engineering knowledge, with the exception of fortification.

The course of instruction extends over a period of two and a half years.

Entrance and Yearly Fees.

	Florins.		£.	s.	d.
Entrance fee	5.30	=	0	9	2
Yearly fees	66.0	=	5	10	0
Special fees for Physical Laboratory . .	8.0	=	0	13	4
,, ,, Mineralogical Laboratory .	2.0	=	0	3	4
,, ,, Chemical Laboratory . .	44.0	=	3	13	4

For entrance to the School of Engineering, the following knowledge is necessary:

1st. Pupils, who, being natives of the Grand Duchy of Baden, wish to pass the Government examination at the regular time, must at least be possessed of the knowledge which can be acquired in one of the grammar schools of the country, and in the two courses of the Mathematical School connected with the Polytechnic.

Proof as to preparation for entrance is to be furnished by means of a certificate, stating that the candidate has fully, and with credit, completed the course of instruction prescribed in a grammar school, or up to the second highest class in a college, and has been promoted out of the second class (course) of the Mathematical School department of the Polytechnic.

2nd. Those native students who have not received their preparatory education at one of the public schools of the country, must, before beginning the special study of Engineering, pass an examination in the following subjects, viz.:

a. The Grammar School course according to the State order dated 31st Dec., 1836, and published in the Government Paper of 1837. No. VIII.

b. Mathematical School.

First Course.

The application of plane and spherical trigonometry.

The higher algebra.

Differential and integral calculus (first course).

Exercises in the treatment of propositions in the differential and integral calculus.

The newer synthetic geometry, especially the theory of conic sections.

The analytic geometry of planes.

Descriptive geometry (first course).

Constructive exercises in do. do.

Practical geometry (Part I.).

Plan drawing.

Field operations in practical geometry.

Mechanics (statics).

Experimental physics.

Repetitions.

Drawing (freehand).

Second Course.

Differential and integral calculus (second course).

Examples in the treatment of propositions in the differential and integral calculus.

Analytic geometry of spaces.

Descriptive geometry (second course).

Constructive exercises in do. do.

Analytical mechanics.
Mineralogy.
Geology.
Mathematical physics.
Exercises (practice) in the physical laboratory.
Experimental chemistry, viz.:
  Part I. Inorganic chemistry.
  Part II. Organic chemistry.
Drawing (freehand).

N.B.—The mathematical and engineering students are further recommended to study modern history, and the history of German literature in the Middle Ages.

Engineering students who pass the Government examination as to learning, have also to undergo a medical examination as to the soundness of their constitutions.

Foreigners and such native pupils as forego all claims to Government employment must before joining the School of Civil Engineering bring proof of their having acquired the knowledge comprised in the two mathematical courses already given, such proof to consist of a certificate of their completion of the second course of the Mathematical School, or of having passed the examination previously referred to.

The successful candidates, after having passed the preliminary or entrance examination, will then have to undergo the following course of instructions:

SCHOOL OF CIVIL ENGINEERING.

First Year's Course.

Strength of materials (Parts I. and II.).
Applied hydraulics and the mechanical theory of heat.
General administrative economy.
Political economy.
Freehand drawing. Landscape painting and water-colouring.
Hydraulic works (first course).
Road construction do.
Constructive examples (first course).
Use and nature of mechanical instruments.
Construction of machinery (first course).
Chemical nomenclature.
Technical course of architecture.
Study of the orders of architecture (first course).
Exercises in architectural projects.
Constructions in masonry.
General history of art.

Second Year's Course.

General study of manufactures.
The general and more important special study of civil law.
Freehand drawing; landscape drawing and water-colouring.
Hydraulic works (second course).
Road construction (second course).
The construction of railways.
Examples and exercises in the construction of hydraulic works and roads (second course).
Theoretical study of machinery.
Theory of the consumption of fuel and heating apparatus.
The manufacture of machines (Part II.).
Mechanical nomenclature.
Study of architectural orders (second course).
Exercises in architectural projects (Part II.).
General history of art.

Third Course (six months).

Hydraulic works (third course).
Road construction do.
The above with special reference to the Grand Duchy of Baden.
Designing important Engineering projects.
Marine works.
Practical geometry (Part II.).
The higher geodesy.
Method of fluxions.

N.B.—Every year excursions are made to examine works either in process of construction or already carried out.

EXAMINATION FOR THE DIPLOMA OF CIVIL ENGINEERING.

At the close of the School year 1867-8 the following were the written questions given at the examination for Diploma in Civil Engineering at Carlsruhe:

A.—*Practical Engineering.*

Question 1.—A company having undertaken to construct a railway in a country having a warm climate, where there is no frost in winter, there occurs a bridge on it over a large river. The bridge is to be for double track, and its site is a place usually flooded at high water to a maximum width of 2,000 metres on either side of the river bed at low water. The sketch No. 1 gives the cross section and water levels. The deeply cut out bed of river is 1,000 metres wide. The least depth of water at centre of stream, 10 metres; difference of level between lowest water and highest flood, 12 metres; the velocity of current at low water is 1 metre per second.

There is a considerable and increasing ship traffic on the river, and steamers ply on it during the high water. On this account the limit for the lowest part of the superstructure is fixed at 10 metres for at least two-thirds of the clear opening of each span. In the 1,000 metres wide navigable part of the river no span shall be less than 60 feet.

It is the interest of the company to adopt the cheapest mode of construction.

Required—1st. The minimum length of bridge to be constructed without raising the high water (by the impediments placed in the way of the flood) by more than 30 centimetres, that stipulation being enforced by the concession.

2nd. The lowest level of the rails over the water surface, so as to diminish the abutting embankments.

3rd. A system of construction requiring as little masonry as possible, as stone and lime are dear, and difficult to be obtained.

4th. A construction which can be prepared, to the finishing, in distant workshops, and be conveyed to the site of erection by water; there to be put together with the least possible manual labour.

The river bed consists of sand and gravel in great thickness, the looded banks of loam and loamy sand.

Question 2.—An embanked regulated stream has a fall 1 in 2,000 or a considerable length. The bed of the stream at bottom is 20 metres wide, slopes of banks 2 to 1, least depth of water 0·8 metre, reatest depth 3·8 metres. The bed is only 2½ metres below the atural surface of ground. On both sides there are embankments ·8 metres high and 2 metres wide at top, slopes 2 to 1. The foot f the slopes stands back 1 metre from the edge of the river bank.

It is required to build a weir on the river for large workshops, which shall fulfil the following conditions:

Eight cubic metres of water per second shall be discharged over he weir to a side watercourse, and shall at all states of the water evel in the river be of such a height over the natural surface of ground that the bottom of the factory watercourse shall be completely formed in the natural soil (in cutting). It is to have a fall of 1 in 8,000. The highest water level may be increased by 0·60 metre when it is considered desirable for the purpose of construct- works for irrigation, consequently the embankment must be cor- dingly raised. The weir is to have an opening for rafts metres wide, and a suitable "shoot." It is to be so arranged that, in consequence of floating timber and ice in the case of high water, the weir can be opened all across the river. The piers are to be few, and to be made of stone or iron.

The entrance to watercourse must be capable of being closed perfectly water-tight, in case of repairs being needed.

In connection with the weir is to be made a road bridge six metres wide over the river and watercourse, also approaches.

The movable part of the weir must be such that it can be removed by ordinary workmen, without special teaching, and on account of mud or silt an axis under water is inadmissible. The construction shall be of solid and durable materials.

The bed of the river consists of loam, and it is to be carefully guarded against the effects of the water fall.

Required—Complete drawings of the entire work, and alternative plans for a different construction should such be practicable or advisable. Also a description of them, in which the necessary hydraulic calculations are given, so as to evince the candidate's familiarity with the progress of modern hydraulic science (and all the other calculations).

Question 3.—A town of 50,000 inhabitants is to be supplied with water in the proportion of 200 litres per head per diem, in addition to which provision is to be made for six public fountains, each throwing a column of water 2½ centimetres in diameter to a height of 10 metres.

Take for example the town of Carlsruhe and surrounding country with the assumed alteration that it lies 40 metres above the mean height of water in the Rhine, and that a 50 metre wide navigable river was placed at the "Alb" (a point between the Rhine and Carlsruhe).

The water supply is to be taken from the Rhine, and pumped up to the reservoir by steam power. It is to be filtered, and the distributing reservoir in which the purified water is collected is to be protected from the action of the air and the heat of the sun.

Required—A project for the foregoing work, giving all the necessary arrangements, with the exception of the laying on of water to the houses.

A general plan for the drainage of the city is also to be given.

The waterworks are to be so arranged as to be capable under ordinary circumstances of supplying water to the garrets of three-storied houses, and in the case of fires to discharge the water over the tops of the houses, and in the event of the burning of a tower to deliver water to the fire engines at a height of 40 metres above the streets.

For this purpose easily-worked hydrants are to be placed at suitable points in the streets, which can also be used in summer *for watering* purposes.

Question 4.—It is required to carry a double line of railway across a mountain valley 56 metres in depth. The steep sides of the valley consist of rock, which can also be found at the bottom at no great depth below the surface. A public road 8 metres wide, and a stream of 12 metres broad and 1½ metre deep at high water have to be spanned over.

The rate of fall towards the outlet of the valley is 1 in 20 in the case of the road, and 1 in 100 for the stream. A lateral deviation is admissible in both cases, but not any alteration as to their heights and levels.

Suitable stone for building is to be found near the works, and the following prices may be assumed correct:—

Earthworks	per cubic metre	½	florin.
Rubble masonry	„	8	„
Ashlar	„	30	„
Timber framed (in work)	„	40	„
Ditto for scaffolding or temporary works		24	„
Cast iron	per 100 lbs.	8	„
Wrought do.	„	12	„

It is required to give projects, and compare their costs, viz.,

a. For a solid embankment.
b. For a stone viaduct.
c. For one in iron.

The manner of construction, and the necessary temporary works, as also the proper calculations for stability in each case are to be given.

Question 5.—Give the rules for the proper construction of retaining walls: their foundations, and the relative dimensions to be given to them.

Question 6.—Give descriptions and particulars of the different methods for calculating the cubical contents of earthworks, and the position of the centre of gravity of the same, in the case of the construction of roads and railways.

Question 7.—Give a short account of the theory of the pressure of earth, and point out the errors and uncertainties to which it is liable.

What form is given to works for supporting retaining earth, according as they are composed of stone, timber, or iron?

What position and extension give the best bearing surface in the case of retaining walls in masonry?

Question 8.—Give description and particulars of the means for protecting foundations from underscouring.

B.—*Applied Mechanics.*

Question 1.—The gas power machine of Otto Langen, which attracted so much attention at the last Paris Exhibition, had a fixed vertical cylinder, long in proportion, and open at the top. The piston-rod is toothed, and catches in the horizontal axis of the shaft of the fly-wheel, which drives a cogged gear. The latter is, however, only coupled with the shaft of the fly-wheel when the piston moves backwards. When the piston is at its lowest position, there is admitted under it a mixture of about 1 part of ordinary coal-gas and 9 parts of atmospheric air; while the piston is raised up to a given height, at which the gas mixture takes fire, and simultaneously the escape opening is closed. In consequence of the great increase in the expansion produced by the heat, the piston is driven further forward; that is to say, so long as the work of expansion of the gas mixture is greater than the atmospheric pressure (no account being taken of the weight of the piston itself).

During the whole of this forward movement of the piston the gear is not coupled with the fly-wheel shaft, the latter and the resistances being then driven only by the *vis-viva* of the machinery in motion: when, however, the piston reaches the highest point where the atmospheric pressure exceeds the elasticity of the gas, it is driven back, and the teeth of the piston-rod become connected with the cogged gear before described; and consequently the unnecessary work done by the atmospheric pressure is transferred to the fly-wheel. At a certain position of the retreating piston the pressure on both faces of it becomes again equal, and the gas escapes through an opened valve during the remainder of the downward passage of the piston.

Required to know what is the theoretical volume of gas (at a temperature of 0°, and under an atmospheric pressure) expended per hour for each horse-power gained, when all particulars, all loss of gas and of heat from cooling down are taken into consideration. Also if the alteration in the condition of the gas mixture took place in a vessel impervious to heat, and when further it is assumed that the burning of the gas mixture is instantaneous (*i. e.* is followed by a constant volume)?

How large must be the driving-wheel of the machine, taking into consideration all these neglected losses and defects, where it is found that in working order it consumes $1\frac{1}{4}$ cubic metres of gas at a temperature of 0° and under atmospheric pressure, per hour, for each horse-power?

The condition of coal-gas may be taken as such that its density $= 0{\cdot}42$, as compared with air taken at 1.

The complete burning of 1 kilogramme producing 10,100 units of heat, the necessary air for which = 14 kilogrammes, and its combustion produces—

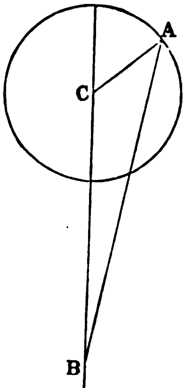
2·2 kilogrammes of carbonic acid gas.
2·0 „ of steam.
10·8 „ of nitrogen.

Hence the specific heat (for a constant pressure) of the gas mixture after the puffing is found to be?

That of carbonic acid gas being given as = 0·216
„ steam . . . . . . 0·480
„ nitrogen . . . . . 0·244
„ the superfluous air present . . 0·238

N.B.—The specific heat for constant volumes can be taken in the roportion of 1 to 1·41 less than those for constant pressure.

Question 2.—A crank C A ($= r$), revolving round an axis at C, connected by a joint at A with the crank-rod A B ($=l$), which its end B traverses a straight line in the irection C B. The rod A B being uniform hroughout its length, and having a mass $= m$. t is desired to ascertain the following informa-ion:—



I. How the mass of the crank-rod can be educed approximately at both ends, that is to ay, to determine the both masses, which when e end points A and B are concentrated in the iddle for the various positions of the crank, ken together would possess the same *vis-viva* the crank-rod.

II. The greatest moment of force (= M) is be determined of the tendency of the crank-d to bend, in any position in consequence of s resistance of inertia to acceleration, in the se where the crank moves with a uniform elocity making n revolutions per minute, under e condition that $\frac{r}{l} = \lambda$ is a small fraction.

N.B. In both questions such approximate calculations will be ufficient as omit the members with λ^2, λ^3 towards unity.

In Question II. the position of the crank should be determined hich has the maximum moment (M), λ being $= \frac{1}{5}$.

C.—*Construction of Machinery.*

Question 1.—Required the necessary calculations for a travelling steam-crane, capable of lifting 120 cwt.

The crane is to be substantially similar to that given in sketch. The carriage is to consist of a wrought iron frame with cast iron centre piece, into which the cast iron turning column is to be fitted.

The plates revolve by means of a level traverse (as also the crane, boiler, and apparatus) round a pivot made fast to the ledge of the column, which can turn, by means of oblique rollers, round a conical circle cast on to the middle piece.

The arm to consist of two pieces of oak timber placed close together, carrying above a movable pulley, and can turn below round a horizontal axis attached to the platform.

The unloading can be varied at pleasure, according to the mechanism shown in sketch. The boiler is to be an upright tubular one, and made fast to the projection at the back of the platform: it, as well as the water-tank, is thus to serve as a counter weight, for which purpose also additional weights may be placed at the back of the platform. The steam-engine is to have two cylinders, working on a bent shaft by means of two cranks set at right angles to each other.

The principal data are as follows:—

	Metres.
Load. Crane is to be capable of raising 120 cwt.	
Distance between extreme bearings (wheels)	3·40
Width of gauge (from centre to centre of rail)	1·50
Length of arm	5·20
Hook in ditto at its highest position extends from centre of turntable	3·50
Height of top pulley above rails	5·50
The distance from hook to centre of turntable, when the arm is brought to its lowest position	5·10
Ditto height of pulley above rails	4·10
Greatest depth below rails to which the lifting-hook can be lowered is	3·20
The greatest height to which the hook can be raised is to within 1 metre of the top pulley.	

This maximum lift is to be effected with a load of 120 cwt. in $1\frac{2}{3}$ minutes.

The piston-drum can have a length of 0·80 metre. The chain shall only be simply unwound. Pressure of steam in boiler to equal 4 atmospheres. Mean velocity of piston 0·80 metre.

For the best proportion of the pulley, one free roll and one movable roll 0·90 may be taken. For the remaining friction of the regular crab, transferred to the drum, circumference about five per cent. of the strain on the chain may be taken.

The following are to be calculated:—

I. Tension length and strength of hoisting chain.

II. Dimension of crab-drum.

III. Strength of steam-engine, and principal dimensions, viz., diameter of cylinder, stroke, crank, and connecting-rods.

IV. Transmission-wheels, besides principal dimensions of cogged wheels and axles.

V. Heating surface of boiler.

VI. Position of boiler, and size and position of counter weights.

VII. Dimensions of turn columns and their pivots.

VIII. Cross-sectional dimensions of arm.

IX. Give a design for suitable machinery for directing and turning the crane by steam-power, without thereby causing any vertical motion to the load being hoisted.

N.B. Should there not be sufficient data given to admit of Questions VI. and IX. being answered, suitable additional data may be assumed, or the principal processes in these calculations may be indicated.

Question 2.—Describe the process of measuring the working performance of a stationary steam-engine :—

1. By means of the break dynamometer.
2. Ditto indicators.

Question 3.—Describe the process of pulling in and out of gear.

Question 4.—Describe the process of reversing.

D.—*Analysis (and its application).*

Question 1. Both functions—

$$e^{x\cos\theta}\,.\,\cos\,(x\,.\,\sin\,\theta)$$
$$\text{and}\qquad e^{x\cos\theta}\,.\,\sin\,(x\,.\,\sin\,\theta),$$

are to be developed in series which shall progress by whole powers, with positive exponents of the variable x.

The conditions of the convergence of these series are to be determined by the aid of the remaining members.

At the same time a precise description is required of the means which analysis possesses for such developments of series, inclusive of the exact proof of the proposition laid down.

Question 2.—In the interior of a circle lies an elementary line whose direction passes through the centre, and it is lighted by a luminous point occurring on the circumference.

When, therefore, the intensity of illumination is proportionate to the sine of the angle of inclination of the ray of light against the given line, and on the other hand proportionate to the square of the distance from the luminous point, on what part of the circumference must the light be placed when the intensity of illumination on the elementary line is a maximum ?

Question 3.—Find the value of the integrals—

$$\int \frac{d\,x}{1 + x^4} \text{ and } \int \frac{d\,x}{1 - x^4}.$$

Question 4.—Determine the surface space between the cissoid $y^2\,(2\,a - x) = x^3$ and its asymtote, as also the entire length of the curve $x^{\frac{2}{3}} + y^{\frac{2}{3}} = a^{\frac{2}{3}}$.

Question 5.—The axes of two right-circular cylinders of equal radii (a) cut each other at right angles.

It is required to find the space occupied by the compound body, also the portion of the one cylinder surface which lies within the other.

Question 6.—How great is the portion of the surface of a sphere $(x^2 \times y^2 \times z^2 = a^2)$ which is cut out by the cylinder $(x^2 \times y^2) = a\,x$.

Question 7.—Integrate the partial differential equation—

$$x\frac{d\,z}{d\,x} - y\,\frac{d\,z}{d\,y} = \frac{x^2}{y},$$

and prove the correctness of the solution obtained; at the same time give a precise and carefully-detailed description of the method of integrating the linear partial differential equations of the first order.

Question 8.—What is the real value of the functions—

$$\frac{\pi}{4\,x} - \frac{\pi}{\pi\,x}$$

$$2\,x\,(e + 1) \quad \text{where } x = 0\,?$$

Question 9.—How is the greatest and least value found of which the function $u = a\,x^2 + 2\,\beta\,x\,y + \gamma\,y^2$ is capable, when the equation between the variables x and y is expressed by—

$$(1 + \lambda^2)\,x^2 + 2\,\lambda\,\mu\,x\,y + (1 + \mu^2)\,y^2 = 1\,?$$

Question 10.—Determine the value of the integral—

$$\int \frac{x^3\,.\,d\,x}{\sqrt{1 + x}}.$$

Question 11.—Integrate the linear differential equation—

$$\frac{d\,y}{d\,x} - a_1\,y_1 = x^4.$$

Question 12.—A common cycloid rotates round the tangent of its summit. What is the size of the surface and the volume of the generating body of rotation?

Question 13.—Find the curve whose property is that the surface between the abscissa and ordinate, the curve and its closing ordinate is proportionate to the curve. What is the curve?

Question 14.—Develop the essential properties of the logarithmic spiral which relate to the tangent and curve.

Question 15.—How is the equation to a curve of a right-circular cone found, whose tangents make constant angles with the line of generation?

E.—*Analytical Geometry.*

Question 1.—Given two right lines intersecting one another, what is the geometrical position for all points for which the proportion of their shortest distance therefrom is constant?

A careful investigation of the position which it must reach when developed is required, as also the determination of the situation of the same in reference to the right lines.

Question 2.—Given a fixed point (O) on the surface of a sphere, and anywhere else in space another fixed point (A).

Through A draw rays cutting the sphere at D and D′, from O draw also rays through D, and make on them the distance $OM = AD'$.

Now when the point D travels over every part of the sphere's surface, where is the position of the point M?

An exact investigation is required of the situation, as also the determining of its special properties.

Question 3.—Given two lines, viz., $OA = a$, and $OB = b$, having a common termination at O, and making an angle between their directions $= \theta$.

Through B draw a line cutting O A in P and O B in Q in the proportions—

$$\frac{OA}{PA} = \frac{BQ}{OQ}.$$

What is the geometric position of the intersecting point M of all such pairs of lines, and what are their special properties in respect to their length and position, in reference to the right lines O A and O B?

Question 4.—Determine the form and position of the curve—

$$(x^2 - 4{,}\,a^2)\,y^2 - 12\,a^2{,}\,x\,(a - y) = 0,$$

with respect to a system of right-angled co-ordinates; and give a drawing of the curve.

F.—*Analytical Mechanics.*

Question 1.—Two smooth planes cut each other at right angles in a horizontal line, one of the planes being inclined to the horizon at an angle $= \theta$.

In the angle formed between the planes rests a heavy homogeneous right-cylinder, of elliptical cross section (whose semi-axes are a and b), in such manner that the major axis is parallel with the horizontal intersection of the planes.

Determine the position of equilibrium of the cylinder, and the pressure which it exerts on each of the planes.

An accurate development of the general principles which serve to solve this problem is also required to be given.

Question 2.—An endless, thin, but heavy homogeneous tube revolves in a horizontal plane, by reason of an instantaneous shock, upon one of its points as a fixed centre.

In the interior of the tube are N, movable material points of the masses m_1 m_2 m_3 and so on to m_n, at the original a_1 a_2 a_3 and so on to a_n, from the centre of rotation.

What motion will the tube and the points assume when the mass of the tube is M_1, its length $= l$, and the central angular velocity w_0?

How is the relative motion of the points circumstanced with regard to each other when the mass of the tube is assumed as nothing?

Question 3.—Two heavy homogeneous spheres of the respective weights G_1 and G_2 are connected by a rod (of no weight) whose direction passes through their centres. The sphere G_1 rests on an inclined plane which makes an angle with the horizon $= \lambda$.

Where must be the centre of the sphere G_2 when the system is in equilibrium for every position? (The distance from the centre being C.)

Question 4.—Two heavy homogeneous spheres G_1 and G_2 are connected by means of a flexible cord which passes over a fixed point A.

The sphere G_1 rests on an inclined plane which makes an angle with the vertical $= \mu$.

Where must be the centre of the sphere G_2 when the system is in equilibrium for every position?

(The length of the connecting cord from centre to centre of sphere inclusive of the radii being l.)

G.—*Descriptive Geometry.*

Question 1.—Given the horizontal projection (A′ B′ C′ D′ E′ F′) of a plane hexagon (A B C D E F), and the vertical projection (A″B″C″) of three of its angles (A B C). To determine the complete vertical projection and the true form of the hexagon.

Question 2.—An ellipsoid revolves on an axis u perpendicular to the horizon. Its centre is M, its vertical semi-axis $= a$, and its horizontal semi-axis $= b$.

Also a cone, through its principal elliptical line, on the horizontal plane and its apex S.

Determine the line of intersection l, of both surfaces, and construct their tangents for a given point on l.

Question 3.—Construct the perspective of a sphere of which the following are the data :—

Position of the eye at		A
Distance	=	A D
Vertical projection	=	M″
Centre of the sphere on picture surface .	=	M
The distance $M_1 M'' = a$		
Radius of sphere $= r$		

Further, the light and shadow line is to be constructed on the surface where the vanishing point of parallel rays is given at S.

Question 4.—A plane ϵ is given by its traces e_1 and e_2, and two points by means of their projections A′ A″, B′ B″.

To find the point C in the plane ϵ, at which, if a mirror be placed, it will reflect to B, the ray of light coming from A.

Question 5.—A revolving ellipsoid is given by means of the projections A′ B′, A″ B″, of its axes of revolution, and the length of C D the diameter of the greatest curve.

Construct the projection of the intersection of this surface with a plane ϵ, whose traces e_1 and e_2 are given.

Question 6.—A right-cylinder resting on a horizontal plane, and a right cone, are given by means of their horizontal projections and the height h of the cone. A vertical picture surface stands inclined towards the axis of the cylinder. The position of the eye, a distant point D, as also the vanishing point S of parallel rays, are all given on the picture surface.

Construct the perspective of the cylinder and of the cone, also the shadows that both cast on the horizontal plane and on each other in perspective.

H.—*Practical Geometry.*

Question 1.—A piece of land of about 1,000 acres in extent, and consisting of 2,000 different properties (holdings), is to be surveyed with the assistance of a theodolite and offset square, and plotted, and the contents of each holding calculated.

Describe the process.

Question 2.—Describe the various methods for staking out curves of circles. What are the advantages and disadvantages of each? And under what circumstances is each most suitable?

According to what convenient formula can tables be calculated, giving the necessary figures for particular methods?

Question 3.—How is a theodolite to be tested and adjusted?

a. When the telescope is reversible and can form a complete revolution on its horizontal axis.

b. When the telescope can form a complete revolution on its horizontal axis, but is not reversible.

N.B.—A particular description of theodolite mentioned in the school text book is referred to.

This information is accompanied by a copy of the

Programm der Gross-Herzoglich Badischen Polytechnischen Schule zu Carlsruhe, (Programme of the Polytechnic School of the Grand Duchy of Baden, established at Carlsruhe,) for the year 1868-9.

The contents of this work are as follows:—

Object and organization of the school.
List of lectures and exercises.
Plans of study of the separate schools.
Subjects of the examinations for diplomas, literary and graphic.
Extract from the rules of the library.
Personal list of the school.

See also the French Report for further information.

WURTEMBERG.

The Kingdom of Wurtemburg has arrangements for the education of Engineers apparently very similar to those of the other North German States; there being a Civil Engineering Department in a Polytechnic School established at Stuttgard.

The following information as to this is communicated by Mr. R. Crawford, Assoc. Inst. C.E.:

For entrance to the Civil Engineering Department of the Polytechnic School at Stuttgard, the student must as a rule have completed his eighteenth year.

He must possess a proper certificate of good moral training, and have acquired the necessary information.

When under eighteen years of age the consent of his parents or guardians is necessary to his entrance into the School.

He must give in a written declaration as to his education, and give evidence of possessing the knowledge without which he could not with advantage attend the professional courses of instruction.

He shall prove that he possesses this preliminary knowledge efore the principal of the particular technical school.

The Engineering Course extends throughout three years.

Fees for Entrance and Tuition.

	Florins.		£.	s.	d.
Entrance fee	5	=	0	8	4
Yearly fees	60	=	5	0	0
Ditto additional when using Chemical Laboratory	5	=	0	8	4
	Krs.				
Servants, yearly	42	=	0	1	2

First Year's Course.

Chemistry, mineralogy, and a knowledge of the structure of the rth.

Practical geometry: instruments for the measurement of angles; lain triangulation, and fixing stations; eradication of errors; igonometrical and barometrical levelling; measuring distances; xamples of foregoing; trigonometrical calculation of heights; echnical mechanics; stability of buildings; elasticity and strength of materials; beam-girders, arches, retaining and "revêtement" walls; solution of practical examples; statics and dynamics of fluids and gaseous bodies, with special reference to their important applications in the practice of Engineering.

Bridge construction (first course): especially bridges in masonry, and retaining walls, with examples; general structures in stone and timber.

Second Year's Course.

Bridge construction (second course): with examples, viz., timber and iron bridges; foundations; management during construction.

General study of buildings (second course), with examples: iron and mixed structures; application of water-power and steam; examples in the construction of machinery; history of the art of building (first course), especially with reference to the Grecian, Etruscan, and Roman manners of building.

Perspective drawing: drawing figures from plaster casts; landscape drawing from examples and from nature, in outline and shaded, in chalks, lead, pen and ink, brush and colours.

Third Year's Course.

Bridge construction (third course): waterworks; road and railway construction, with examples; staking out; calculating earthworks.

History of the art of building, with examples (second course): especially with reference to Roman and Gothic buildings.

The following publications on this subject are in the Library of the Institution:—

"Programm der Königlich Württembergischen Polytechnischen Schule, in Stuttgart." (Programme of the Royal Polytechnic School of Wurtemberg, established in Stuttgart, for the years 1868-9.)

"Jahres-Bericht der Königl. Polytechnischen Schule zu Stuttgart; für das Studienjahr 1867-8. Mit einer Abhandlung zur Theorie der Tonnengewölbe von Professor Baurath von Hanel." (Annual Report on the Stuttgart Polytechnic School, for the Session 1867-8. With an Essay on the Theory of Vaults, by Professor von Hanel.) Stuttgart, 1868.

See also Report of the French Commission, Translation, p. 172. The following is an extract from this:—

> The division for builders and architects comprised, in 1864, about 40 pupils. The studies are regulated so that, on completing their first year of special studies, they have to pass one year in the practical exercise of their profession. After this novitiate they assume the title of builders

(*Werkmeister*). When they have passed their fourth year at the school, and have worked one or two years under the direction of an architect, they can take the title of architect, and are allowed to undertake the execution of works for towns.

The division of engineers had, during the same year, from 60 to 70 pupils, and an examination of the projects which they executed, and of the very detailed and most complete studies of bridges of all kinds made by them, prove that they have been judiciously taught, and have studied well.

SAXONY.

M. Hartig, Secretary to the Society of Engineers of Saxony, sends several publications, with the following remarks:

The Engineering education in Saxony is always a combination of theory and practice, carried out in somewhat different forms for the different classes of Engineers.

For example, those who wish to learn Land Surveying or Railway Engineering must at first attend all the classes of the Saxon Polytechnic School and then go into practical employment; those who intend to be Architects or Mechanical Engineers have to pass a practical course, either before they go to the Polytechnic School or after they have finished with the general department of the same.

The Government aid given in support of this education is considerable, amounting to sixty or seventy per cent. of the total expenses.

The following publications have been received:—

"Die Königliche Polytechnische Schule (Technische Bildungs anstalt) zu Dresden, während der ersten 25 jahre ihres Wirkens geschildert; von Prof. Dr. Hülsse. Dresden, 1853." (An account of the first twenty-five years' working of the Royal Polytechnic School, or Establishment for Technical Training, at Dresden.)

"Organisations plan der Königlich Sachsichen Polytechnischen Schule zu Dresden; genehmigt durch Verordnung der Königlichen Ministeriums des Innern, von 31 Januar, 1865." (Plan of Organization of the School, sanctioned by order of the Minister of the Interior, 31 January, 1865.)

"Jahresberichte," &c. (Annual Reports of the School for several years.)

"Katalog der Bibliothek." (Catalogue of the Library.) Dresden, 1864.

By these documents it appears that the Royal Polytechnic School at Dresden comprises the following divisions:

I. A general course, in which are taught all the general *branches* of science accessory to the various technical departments.

II. Four technical subdivisions—namely,

- *a.* The Technical Mechanical School, for those persons who propose to be manufacturers, directors of manufactories, or constructors of machinery, in any of the branches of technical mechanics.
- *b.* A School of Engineering, for those who intend to practise road, railway, bridge, or hydraulic construction, as well as for surveyors.
- *c.* A School of Technical Chemistry, for manufacturers, foremen, &c., in any of the various branches of chemical manufacture.
- *d.* A normal School for the training of future teachers of mathematics, natural philosophy, and technical subjects.

There is also an extra course for drawing.

The fee paid for each full course in one division is twenty thalers, half-yearly, for a native of the country, and thirty for a foreigner.

The students are allowed to visit national museums and collections, to make excursions to public works, railways, and technical establishments, and to make extensive surveys.

Periodical examinations are held, and certificates of proficiency are given.

An extract from the Government Regulations for the employment of their technical servants gives information as to the conditions prescribed for State appointments.

The candidates for Government employment in any branch of Engineering work must in the first place be in possession of certificates showing their having acquired the necessary preliminary knowledge; and secondly, must show that they have been engaged for at least three years in the successful practice of the occupation in which they seek employment.

They must then undergo a State examination for either of the four following occupations:

I. Geodesy and surveying.
II. Engineering construction (roads, railways, hydraulic and bridge works).
III. Mechanical Engineering.
IV. Architecture and agricultural construction.

Particulars of the subjects examined upon will be found in the pamphlet.

Certificates are given of the passing of the State examinations; but they do not give any claim to employment by the State.

M. Hartig has also sent some documents relative to the "Königliche Berg Akademie," or Royal School of Mines, at

Freiberg, the object of which is exclusively to train st
mining and metallurgical operations. Further informati
ing this school will also be found in the "American
Mining," July 25 and Aug. 1, 1868 (in the Library, Ins

There is also a "Königliche Hohe Gewerbeschule, Ba
Schule, und Workmeister Schule," *i.e.*, a Royal High
School, and a School for Artizans and superior Workmen,
at Chemnitz, of which a programme is sent.

Additional information as to the education in Saxo
found in the Report of the French Commission.

SOUTH GERMANY.

BAVARIA.

HE only information received directly by the Council as to ngineering education in Bavaria is contained in a Programme of he Polytechnic School at Munich (Programm der Polytechnische chule zu München), for 1868-9.

From this it appears that the school was founded about forty ears ago, and contained originally three general classes, and a ingle special technical school for construction and Engineering. In pril, 1868, however, the scope of the school was enlarged by oyal decree, and it now contains the following branches:

General Education.

Mathematical sciences.
Natural sciences.
The sciences connected with construction and Engineering.
The arts of design.
eneral branches of knowledge.

Special Courses.

onstructive Engineering.
gricultural Engineering.
Surveying.
Architecture.
Mechanical Engineering.
Technical chemistry.

The details of the studies and the general arrangements of the ool will be found in the programme, which is in the Library of Institution.

Information as to the Bavarian Schools is also given in the lies to Lord Stanley's Circular. The "Course of Engineering" the Munich Polytechnic School is given as follows:—

he knowledge of construction in general, and applied specially to dges, roads, railways, canals, and water courses.

Construction and designing.
The theory of stone-cutting.
Practical geometry.
Drawing of sections of stones, walls, &c., and modelling of the same in plaster.
Architecture, after the antique.

The school is entirely maintained by the State, and stipends are given to poor students. There are Polytechnic schools also established at Nuremberg, having especial reference to metal-work, and at Augsburg for textile manufactures.

Further information as to the Munich Polytechnic School, and other educational establishments in Bavaria, will be found in the French Report.

BOHEMIA.

The following documents have been sent by M. Krejčý, Rector of the Polytechnic Institute at Prague:

"Personal Staud der Königlich-böhmishen Polytechnischen Landes Institutes in Prag, und Ordnung der offentlichen ordentlichen und ausserordentlichen Vorlesungen an demselben, 1863-4."

"Anzeige der Vorlesungen und der Personalstaudes am Polytechnischen Institute des Königreiches Böhmen. Studienjahre, 1866-67, 1867-8."

(Programmes of the lectures and educational staff at the Polytechnic Institute of the Kingdom of Bohemia.)

"Jahres-Bericht über der Zustand und die Leistung der Polytechnischen Institutes des Königreiches Böhmen, 1864-5, 1865-6, 1866-7."

(Annual Reports on the state and results of the Institution.)

From these documents it appears that this Institute comprises four divisions, viz.:—

For hydraulic and road construction, five years' course.
For architecture, five years' course.
For machinery, four years' course.
For technical chemistry, four years' course.

In addition to which many subjects are taught that are not included in the special courses.

The programmes give particulars of prize problems in Engineering Construction given at the examinations.

The Rector of the Institute also adds some further information, of which the following is a translation:—

The annual expenses amount, on an average, to 130,000 florins (Austrian currency), and are paid out of the funds of the country with the assistance of the school fees.

The school fee is 50 florins annually, from which poor students, according to the progress they show, are either entirely or partially freed. The actual receipts in fees amount, on an average, to 13,000 florins, so that the expense to the State is annually 117,000 florins.

The average number of students is 650.

The expense for each student is about 180 florins.

The following gifts are established in the Institution :—

1. The Gerstner Travelling Gift, for passed technical students, 600 florins annually, in silver currency.
2. The Geilling Gift, for technical students who devote themselves to bridge construction, 120 florins annually, Austrian currency.
3. The Pollock Gift, for very industrious technical students, 42 florins annually.

In addition to these there are many other private foundations, the greater part of which are in the gift of Government.

At present forty-five technical students are in the enjoyment of these privileges.

There are no free admissions.

It very seldom happens that the expenses of students are borne by private industrial firms.

The appointment of the professors and teachers is by competition or selection. The qualifications for such appointments comprise a distinguished scientific and technical training, to be exhibited by corresponding scientific work, or by documentary proof of considerable experience in scientific teaching.

The students board and lodge in private houses; the educational body superintend their moral behaviour, but their religious exercises are left to themselves.

Further particulars of this Institution will be found in the Translation of the French Report, page 122.

AUSTRIA.

With regard to engineering education in Austria there is information from two quarters.

The first is from an Engineer at Vienna, M. Nagel, who writes, through Mr. Geo. Giles:

The system of education of Engineers in Germany and Austria is in general as follows:

After having received in the "Unter and Ober Realschüle" (Upper and Lower ordinary schools for practical objects) an elementary education, the students enter a Polytechnic Institute, where they receive, during five or six years, a technical education.

In most of these Institutes they have, at the end of this time, to undergo a first examination.

After this they pass a kind of apprenticeship to obtain practical knowledge of their respective branches of Engineering, by serving as volunteers for one or two years either on Government or private works.

At the expiration of this time, and frequently after having travelled for professional improvement, the second examination has to be made; after passing which the student is entitled to enter Government service or begin the practice of a Civil Engineer.

The accompanying programme of the Polytechnic Institute at Vienna will explain the nature of such institutions.

The following additional statement has been received through Mr. Abel:

Engineering Education in Austria.

There are in Austria six principal schools for Engineering education, namely, the Polytechnic schools at Vienna, Prague, Gratz, Ofen, Brünn and Lemberg.

These are supported partly by the State, and partly by the school fees; for the school at Vienna the State advances annually a sum of from one hundred to one hundred and thirty thousand florins.

The principal and best school is that at Vienna, of which the prospectus marked (A), and statute of organisation marked (B), are sent herewith. The organisation has lately been remodelled on the plan of that of the Carlsruhe school.

Those students who enter as pupils in a practising engineer's office are not generally required to pay fees.

Those students who, on completion of their studies, desire to enter the service of the State, have, under the existing regulations, to pass the so-called "State Examinations" after having passed the ordinary school examinations, even if the certificates that they receive on passing the latter are of the first class.

If under the present rules the "absolved" student desires to obtain the rights and title of a "sworn and authorised Civil Engineer," he must be able to prove that, after leaving the school, he has undergone practical training for a certain time, and must pass the State examination, after which he is sworn in (further information respecting the nomination of "sworn and authorised Civil Engineers" will be found in the accompanying municipal rules and regulations of the 27th August, 1861, and 31st May, 1864, marked C′).

At present, however, as the school has been reorganised (since the year 1865), and it has been determined that at the end of the course of study every scholar who desires it shall be subject to a more strict general examination, the directors are in negotiation with the ministry, in order to arrange that, for the future, a student who shall have obtained good certificates on passing the above examination shall be absolved from passing the State examinations before being sworn in as an authorised civil engineer. This point is, however, not yet decided, and the question as to what title such a student shall receive is also an open one. It is said, however, that he is to be called a "Despensiter Techniker" for such and such a branch of the engineering profession.

The certificates received by the students at the end of the school term, as also the amount of general knowledge required before entering the school, will be found in the prospectus (A).

The following information is taken from the work named above, which is preserved in the library of the Institution, and is entitled "Programm des K. K. Polytechnischen Institutes in Wien, für dar Schuljahr, 1867-8. Wien, 1867, Verlag des K. K. Polytechnisches Institutes."

The object of this Institute is to furnish a thorough theoretical, and, so far as practicable, also practical education for certain special occupations.

The Institute comprises the following divisions:

(A.) The general division, in which such knowledge is taught as *serves for* the basis of the following technical objects.

(B.) The special school for roads and hydraulic works (engineering).

(C.) The special school for architecture.

(D.) The special school for the construction of machinery.

(E.) The special school for technical chemistry.

The pupils are either regular students, who are usually inscribed for full education in one of the four special schools; or extraordinary students, who only attend certain courses of lectures.

The ordinary students are examined for admission in arithmetic, algebra, geometry, plane and spherical trigonometry, analytical geometry of two dimensions, geography, history, physics, natural history, geometrical and free drawing, and facility in German composition.

Each regular student has to pay a fee of fifty florins (£5) annually. This may be remitted in special and deserving cases.

The progress is tested by periodical examinations, and the transfer from the general to the special schools is determined in the same way.

The capacity of the student for exercising his profession is tested by a strict final examination, to show that he possesses all the theoretical and practical knowledge comprised in the course he has followed.

On the satisfactory passing of this examination, a diploma is given.

In addition to the course followed in the school, the student must also show acquaintance with political economy, commercial law, and book-keeping.

The examinations are partly in writing and partly *vivâ voce.*

The following is the programme of the studies in each division of the establishment:

I. REGULAR INSTRUCTION.

DIVISION A.

GENERAL SCHOOL.

First Year.

Mathematics (first course), Algebraical analysis, Analytical Geometry, Elements of the Differential and Integral Calculus.
Descriptive Geometry.
Constructive Drawing.
Inorganic Chemistry.
Zoology.
Botany.
Mineralogy.
Free Drawing.

Second Year.

Mathematics (second course), Differential and Integral Calculus.
General and Technical Physics (first course).

Technical Mechanics.
Practical Geometry.
Topographical, Constructive and Technical Drawing.
Free Drawing.

DIVISION B.

SCHOOL OF ENGINEERING.

First Year.

Building; materials and the art of construction.
The Mechanics of Construction (first course), general division.
Mechanical Technology.
Technical Physics.
Analytical Mechanics.
General knowledge of Machines.
Ornament Drawing.

Second Year.

Earthworks—setting out; Tunnelling.
Construction of Bridges.
Exercises in Construction.
The Mechanics of Construction (second course); theory of Bridg
Spherical Astronomy.
Higher Geodesy.
The knowledge of Ground and Soils.

Third Year.

Road and Railway Construction.
Hydraulic Construction.
Railway Architecture.
Geology and Mineralogy.
Law, as relating to Buildings and Railways.

DIVISION C.

SCHOOL OF ARCHITECTURE AND BUILDING.

First Year.

Constructive Architecture (building materials and construction).
Exercises in Construction.
Architecture as a fine art (first course—ancient Architecture).
History of Architecture (first course).
Technical Physics.
Ornament Drawing.

Second Year.

Architecture as a fine art (first course continued).
History of Architecture (first course continued).
The Mechanics of Construction (first course—general).
Mechanical Technology.
General knowledge of Machines.
Geology.
Ornament Drawing and Modelling.
Perspective.

Third Year.

Architecture as a fine art (second course—the Middle Ages a Renaissance).
Agricultural and Industrial Architecture.

History of Architecture (second course).
Summary of Road and Hydraulic Construction.
Law, as relating to Buildings and Railways.

DIVISION D.

SCHOOL OF MACHINERY.

First Year.

Theory of Machines (first course).
Construction of Machines (first course).
Analytical Mechanics.
Technical Physics.
Summary of Architecture.
Constructive Drawing.

Second Year.

Theory of Machines (second course).
Construction of Machines (second course).
General ideas on Road and Hydraulic Constructions.
Mechanical Technology.

DIVISION E.

SCHOOL OF TECHNICAL CHEMISTRY.

First Year.

Organic Chemistry.
Analytical Chemistry.
Exercises in the Laboratory.
General and Technical Physics (first course).
Technical Mechanics.

Second Year.

Chemical Technology for inorganic bodies.
Exercises in the Laboratory.
Technical Physics.
General knowledge of Machines.
The knowledge of Goods and Merchandize in general.
Methods of Investigation.
Comestibles, Technical Raw Materials.

Third Year.

Chemical Technology of organic bodies.
Laboratory Exercises.
Agricultural Chemistry.
Mechanical Technology.
General ideas on Architecture and Building.

DIVISION F.

SUBJECTS WHICH DO NOT BELONG TO ANY SPECIAL SCHOOL.

Agriculture, Farming, and Forest Culture.
Zoology.
History.
History of German Literature.
German Classics.
Rhetoric and Composition.

History of the Industrial Sciences.
Applied Æsthetics, or general theory of Art.
Political Economy.
Commercial and Maritime Law.
Statistics; comparison of European nationalities.
Austrian Law.
Book-keeping.
General Civil Law.
Exercises in business problems.

II. EXTRAORDINARY INSTRUCTION.

Elliptic functions.
Higher branches of the Differential and Integral Calculus.
Calculation of Planetary and Comet Orbits.
Geometry of Position, and Graphical Calculation.
Graphical Statistics.
Political Arithmetic and Life Assurance.
Applied Electricity.
Mathematical and Physical Crystallography.
Anatomy of Plants and Microscopy.
Physiology of Plants in its application to Agriculture.
Palæontology.
Chemistry of Alcohol.
Manufacture of Pharmaceutical Preparations.
Psychology and Logic.
Commercial Geography.
History of Political Economy.
Statistics and Economy of Commercial Traffic in Austria.
Surgical Aids in cases of Accident.

III. LANGUAGES AND FOREIGN LITERATURE.

French.
English.
Italian.
Persian.
Turkish.
Arabic.
Stenography.

EXCURSIONS.

Frequent excursions are made to illustrate the study of Botany, Zoology, Geology, Mechanical and Chemical Technology, Land and Forest Culture, Soils and Ground, Machinery and Construction, and Surveying.

A catalogue of text-books used in the various courses is also appended, and will be found in the library.

See also Replies to Lord Stanley's Circular, page 416.

The document marked C′ accompanying Mr. Abel's memorandum (which appears to be an extract from some State paper of official notifications) contains Government regulations respecting the authorised employment of Civil Engineers, publicly and privately. From this the following information is taken.

The persons, who, having been examined and sworn, are authorised by the Government to practise, belong to three classes:

1. Civil Engineers for all kinds of building construction.
2. Architects.
3. Land surveyors.

Civil Engineers are authorised to undertake the following work:

a. To take surveys and measurements and calculations of all kinds, and to make plans relating thereto.

b. To furnish plans, designs, and estimates for buildings, roads, and hydraulic works and machinery.

c. To carry out new works or repairs, and to direct the plans and machinery for the same.

d. To value buildings, sites, materials, and machinery.

e. To undertake investigations and experiments on scientific questions, on the subjects of construction, physics, and mechanics; calculations and drawings on the same; reports and advice.

f. To examine and certify to the correctness of plans, surveys, measurements, &c.

Architects are confined to so much of the above-named work as has to do with architecture.

Surveyors are only authorised to conduct all work in their proper sphere.

No person in the regular employ and pay of the State can undertake special work for other persons.

To obtain the authorised privilege of practising in either of the grades, the candidate

1. Must be twenty-four years of age, and capable of managing his own affairs.
2. Must be an Austrian subject.
3. Must be of good character.
4. Must understand the language of the country for which the concession is given.

For the practice of Civil Engineering, the candidate

5. Must show that he has passed through all the technical studies which are prescribed for the State Engineers.
6. Must have had five years' technical practice, either in the constructive department of the State, or with an appointed Civil Engineer or architect. Two years of this may have been passed during the studies.
7. Must pass a strict theoretical and practical examination in practical geometry, mechanics, and the theory of machines in

building, road, and hydraulic construction, and the various sciences appertaining thereto.

The special qualifications for architects and surveyors will be found in the book itself.

The authorisation may be forfeited by certain specified acts.

Authorised persons in either of the grades may be borrowed by the Government at any time under certain conditions, and at fixed rates of pay.

Further information as to the Vienna Polytechnic School will be found in the Report of the French Commission; and as to the *Imperial and Royal Technical Institute at Brünn,* in the Replies to Lord Stanley's Circular, page 422.

ROUMANIA.

BUCHAREST.

In regard to this place there is a letter from the Minister of Public Works, forwarded through Sir Charles Hartley. The information contained therein is as follows:

I. The pupils destined to pursue the profession of Civil Engineering follow several courses after having finished their studies at the schools (Lycées), *i. e.*:—

They either continue their special theoretical studies at the faculty of sciences, or they complete their practical instruction in the Corps of the Ponts et Chaussées, where they may be admitted as student-engineers, and, after certain studies and certificates of aptitude, may be promoted to the grade of engineer.

Or, having finished the studies of the schools, they may enter, after examination, into the Technical School of Ponts et Chaussées, under the direction of the Minister of Public Works, where they will follow for three years elementary studies, as well theoretical as practical, sufficient to be admitted as conductors of works in the Corps of Ponts et Chaussées. Some among these latter, having marked aptitudes, continue their studies during the service, and may pass, after examination, to the grade of engineer.

Or, finally they go abroad, where they finish their studies in the special schools of the "Génie Civil," and, after having obtained a diploma, they are admitted as engineers in the service of the State.

II. The interest taken by the Government in the young men who purpose to become Civil Engineers, consists in subventions, allowed to them through the duration of their studies in the country, and in the pecuniary aid distributed to the most meritorious, who go to complete their studies abroad.

III. No one can be admitted to the capacity of Engineer of the State, or practise privately, without having passed an admission-examination on technical matters. The pupils who have finished their studies in one of the special foreign schools, and who have obtained the diploma, are excused from these examinations.

It must be remarked that in this country there are three classes of engineers:

(*a.*) Engineers of public works, who are generally in the service of the State, and are only admitted thereto after examination, and on the exhibition of diplomas.

(*b.*) Engineers of public or hydraulic works, who practise their profession in the service of companies, to which they are admitted according to rules fixed by the said companies.

(*c.*) Topographical engineers, who are only admitted to practice after an examination passed before a commission.

IV. The establishments where engineers are educated in this country are at present two in number, viz.:

1. The Faculty of Sciences, section of mathematics, where the pupils acquire theoretical knowledge of calculations, geometry, astronomy, mechanics, physics, and chemistry, which they apply afterwards by a kind of apprenticeship with Engineers of the State.
2. The Technical School of Ponts et Chaussées, attached to the Ministry of Public Works, in which the students receive a theoretical and practical instruction; limited, however, to what is necessary to train the technical agents necessary for the service of the State. The instruction in this school comprises mathematics, mechanics, descriptive geometry and its applications, drawing, physics, and chemistry, applied to the construction of bridges, roads, navigation, railways, architecture, &c.

V. Every student having undergone the necessary examinations in the two schools above named may receive a diploma or certificate declaring his capacity to be admitted into the public service, or to exercise his profession privately.

VI. The system of apprenticeship is practised with the engineering students, who have to pass at least two years in active service before admission to the grade of engineer.

It is also practised for the conductors who commence their practical studies along with private engineers, and continue them by completing the theoretical knowledge confirmed in the programmes, until they can pass the examination for admission, or obtain the certificates of capacity. The duration of the apprenticeship is not fixed, and no premium is paid for the instruction.

VII. As stated in Art. 3, no one can practise the profession of Engineer in the service of the State, or privately, without having passed examinations of admission, or obtained the diploma of one of the special schools at home or abroad, recognised in this *capacity*.

SWITZERLAND.

THE technical education in Switzerland is proverbially complete. Information upon it may be found at much length in the important work of Mr. Scott Russell;[1] and special particulars, in regard more particularly to the education and status of Engineers, have reached the Institution from several quarters.

The following Paper is by Mr. Henry Samson, Student of this Institution, who is now engaged in practice in this country, but was formerly a pupil at the Zürich Polytechnic School:

SOME REMARKS on the ENGINEERING EDUCATION and on the LEGAL POSITION and STATUS of MEMBERS of the PROFESSION ABROAD.

ZURICH, SWITZERLAND.

In the following remarks I propose to describe the course of study prescribed by the Senate of the Federal Polytechnic College in Zurich, and then to speak of the legal position and status of the members of the profession in that country. Before proceeding, I may as well say that my knowledge was gained by personal residence and study, both at this place and at the Polytechnic at Hanover, for, on the whole, a term of four years.

The Polytechnic at Zurich is a Government Institution kept up by the whole of the cantons in the Swiss Federacy; the Canton of Zurich provides the building as a set-off against the benefit it derives from the residence of so many professors and students; the building has been put up at a cost of about £120,000, which sum is comparatively large for so small a canton, the whole of whose inhabitants do not number as many as some of our large towns.

The College is presided over by a Committee of the Federal Council, who nominate one of the professors as rector (head master); the latter, acting as chairman of a committee of the professors, takes the actual management of the institution. The fees paid by the students are nearly nominal, and such as they are, are often remitted. There are also certain funds set apart for the purpose of assisting deserving students, but as these things are all managed in a very quiet sort of way, I did not gain much information on this point.

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[1] See Part III.

The professors are mostly Germans, whose salaries are not such as would attract any great talent in this country, but for Switzerland are considered high. One or two of the higher paid receive about £700 a-year, but there are many very good men who do not receive nearly that sum. Of the students admitted, the number of the foreigners bears a comparatively high ratio to that of the Swiss, and the former come from all parts of the world, particularly from Germany, Sweden, Norway, the United States of America, the Brazils, England, &c., &c.

Both French and German being the languages spoken in different parts of Switzerland, it has been found necessary to have the principal lectures in the first two courses held in both those languages; but as ample opportunities are given for acquiring the German tongue, the lectures in the higher classes are only conducted in that language. The College is divided into two primary divisions, viz.: the Preparatory Class (one year) and the Polytechnic Proper.

The greater number of Swiss are at once admitted into the Polytechnic Proper, having previously received a thorough preparatory education in special divisions of the National schools set apart for the purpose. The Preparatory Class is mainly for the French and Italian Swiss, whose schools, on the whole, are not so good as those of the German Swiss, and also for foreigners, who, by entering this class, have an opportunity of acquiring a thorough knowledge of the German language before entering upon their actual professional studies in the Polytechnic Proper.

The course of instruction in the Preparatory Class covers a large extent of ground, as the students are considered to be already well grounded in that which is taught in this class, and only want rapidly taking through the course in order to well understand the subjects they will be taught in the following courses. The ground gone over in this class comprises—Geometry, commencing from the beginning and completing plain geometry; algebra, from the fundamental rules to the beginning of the differential calculus; natural philosophy, with experiments; the elements of surveying, with the use of the simpler implements, such as the level, &c.; mechanical drawing, and the elements of descriptive geometry. During the whole of this course, which lasts one year, the students are tested by monthly examinations, and are required to pass a stiffish examination at the end of the year, before being admitted into the Polytechnic Proper; if they fail they are allowed one year more, but if they fail to pass at the end of the second year they are not allowed to continue their studies. The age of admission to the Polytechnic and to the preparatory course is fixed at 17 as a minimum, but many exceptions are made; still the greater part average much higher, the average age at admission being about 20: the reason of this being, that a great many have already entered upon some practical course before coming to the Polytechnic, but finding that they cannot compete with those Engineers turned out by the College, come there at an advanced age (comparatively speaking).

Besides the regular students there are some who, although not absolutely of the body of the institution, are allowed to attend such of the lectures as will tend to advance them in their respective trades; this class is not numerous, and consists mainly of young men of the town.

The Polytechnic Proper is divided into the following departments, viz.:—

1. Department of Civil Engineering (3 years).
2. Department of Mechanical Engineering (3 years).
3. Department for Architecture (3 years).
4. Department for Chemistry (2 years).
5. Department for Forestry and Agriculture (2 years).
6. Department of General Sciences.

I will endeavour to describe the course of study comprised in the first of these departments, namely, that of Civil Engineering, merely remarking, that where practicable, all the departments work hand in hand, and are gathered together for certain lectures, such as mathematics, &c.

Each class in each department has a separate drawing (designing) room, but for the lectures the classes have to go to the rooms assigned to the different professors.

For the first year of the Civil Engineering class the programme includes—Mathematics (the differential and integral calculi), natural philosophy, descriptive geometry, chemistry, the rudiments of engineering and building construction, surveying, the use of the surveying instruments, mineralogy, and the beginning of geology; the student is also made conversant with the nature, manufacture, &c., of the different materials, such as wood, iron, lime, cement, stone, bricks, &c. During the winter months the theory of surveying and the use of the higher instruments is completely gone into, and during the summer this knowledge is practically put to the test by extensive surveys being undertaken; a considerable amount is likewise spent in designing roofs, houses, towers, retaining walls, wooden bridges, cranes, crabs, &c. During the whole of the first year frequent examinations (written) are held in the various matters of study; besides these written examinations, each professor has frequent meetings to which he invites a certain number of his class at a time; these meetings, at which the professor examines *vivâ* *voce*, I consider of great value, as they enable the student to inquire as to anything he may not have understood during the course of the lecture.

Each lecture is as far as possible illustrated by experiments and models, of which latter the College possesses an excellent collection. In the cellars of the establishment there is fitted up a set of good tools, such as lathes, drilling machines, vices, &c., worked by steam-power, and a skilled mechanic is employed to teach and superintend in this department.

The second year is taken up with lectures on railway construction, roads, bridges, &c., and a great portion is devoted to designing under the personal superintendence of the professors. The higher branches of mathematics are likewise continued, and hydraulics, water-wheels, inclines, &c., are gone into.

The course of study in the third year comprises lectures on the calculation of strains in roofs, bridges, &c., the theory and practice in machinery, docks, waterworks, &c.

During the whole term of the three years, the student is enabled to get a great deal of valuable information relative to the theory and practice of the Engineering profession.

At the end of the term, examinations are held for the diploma given by the institute; this diploma certifies that the holder has gone through the course prescribed by the Federal Council, and that he is "qualified" to act as a Civil Engineer.

The question as to the "legal" position of the members of the profession is one of very great difficulty; there seems to be no hindrance put in any man's way, nor are those acting as engineers for private undertakings required to produce any evidence as to their qualifications by the Government; this class is, however, not yet very numerous, which I account for by the fact that private enterprise does not run very high in that country. I should, however, think that in time only those engineers who have received some diploma or other will be considered duly qualified "Civil Engineers." Pupilage, such as is usual here, is not yet known in the professions in Switzerland.

With regard to the "status" of the Civil Engineering profession, I beg to remark that this term can only be applied in this case within very wide limits. In Switzerland very little distinction of classes is made, but as far as I was capable of judging, I should say that the profession is held in the same estimation as that of Law and Medicine.

HENRY SAMSON, *Resident Engineer*,
Grimwith Reservoir,
near Skipton, Yorkshire.

The following letter from M. C. Kappeller, President of the Zurich Polytechnic School, gives some further particulars.

(Translation.) "*To Mr. Forrest, Secretary to the Institution*
"*of Civil Engineers, London.*

"HONOURED SIR,

"General Dufour, of Geneva, laid before us some time ago a circular from the English Institution of Civil Engineers, in which questions were asked and information required respecting different Engineering Schools and their organization. We have the honour herewith to tell you that we are now in a position to give you an account of the circumstances of the formation of our own school; not, however, of the arrangements of any other institution: for the remainder in Switzerland, with the exception of the Special School, in Lausanne, are still more unformed.

"You will learn from the accompanying pamphlet all that concerns our establishment—viz. the groundwork of the Polytechnic Institution; rules with illustrative examples; exceptional and diploma regulations: with a programme of instruction which is desirable and necessary, as well for the general organization of the schools as for the Engineering department in particular. For further information as to the existing corporate divisions of Civil and Mechanical Engineers, and also by way of reply to your questions, the following remarks must suffice.

"Since its formation in February, 1854, the Polytechnic Institution has, with a trifling additional assistance, supported itself, receiving originally an income of 150,000 francs per annum which is now increased to 250,000 francs; the entire current budget of the institution is 300,000 francs, which with that portion of the money that falls immediately to the professors amounts to 350,000 francs.

"As in all the schools, so also in the Engineering department, there are exceptions to the rules. These may be found among the exceptional regulations, Appendix III., page 5.

"The course of study for Civil Engineers is for three and a half years; for Mechanical Engineers three years, any former instruction not reckoned, and embraces all points of instruction which are thought necessary by the profession to produce theoretically a good Engineer.

"All courses of study which pertain to the strictly economic sciences are obligatory on the student.

"At the close of every year promotions take place. The diploma examination at the end of the course is not compulsory, but the honour of undertaking it is open to every student. Nevertheless, the students of the upper course at least avail themselves of this examination, and the greater part come out well. The remaining pupils receive parting testimonials, marking their attainments, &c. The numbers run from six to one, of which six is the best position. The departments over which the diploma-examination extends, together with the whole proceedings, are subject to the regulations for the diploma-examination (Appendix II.). The diploma forms a mark of merit for good conduct during the course of study; but it is only awarded to those whose knowledge is unmistakeably above the level of ordinary attainments.

"Neither diploma nor testimonial necessarily qualifies the student for State service, but they are a good and certain recommendation. It is nevertheless open to any free professional man to gain what his attainments may deserve.

"It is not absolutely necessary to go through this process of apprenticeship to become a Civil Engineer. The school gives much more than theoretical knowledge. It is still forbidden to bear any professional title in Switzerland; the principal requirement for the practice of any vocation in our country being a theoretical and practical capability. For the professional man this must form his call.

"For educational purposes particular and specially-prescribed books are used. The library of the Polytechnic Institution, on which a large sum was spent, contains, besides the ordinary periodical publications, the newest and most interesting works on professional subjects, the use of which is free to the students. The accompanying catalogue will give you some idea of its contents.

"C. Kappeller,
"*President of the Swiss Institution.*"

The following documents accompanied M. Kappeller's letter; they will be found in the Library of the Institution:—

Appendix I.

"Loi Fédérale, sur la creation d'une École Polytechnique Suisse, du 7 Février, 1854."

Appendix II.

"Règlement de l'École Polytechnique Suisse, 28 Février, 1866."

"Rapport du Conseil de l'École Polytechnique Suisse, au Conseil Fédéral sur le projet d'un nouveau règlement de l'École, 26 Dec., 1865."

Appendix III.

"Règlement pour les examens d'Admission à l'École Polytechnique Fédérale en exécution des Art. 13 et 14 du Règlement de l'École du 26 Février, 1866." (There is also a copy of each of the above works in German.)

Appendix IV.

"Regulativ für die Diplomprüfungen des eidgenössischen Polytechnikums in Zurich." (Regulations for the examinations for diplomas in the Swiss Polytechnic School at Zurich.) No date.

Appendix V.

"Programm der eidgen. Polytechnischen Schule für das Schuljahr, 1868-9." (Programme of the Swiss Polytechnic School for the Session 1868-9.) Zurich, 1868.

Also, "Verzeichniss der Bibliothek des Schwerzerischen Polytechnikums." (Catalogue of the Library of the Swiss Polytechnic School.) Zurich, 1866.

There is a further communication in regard to the education in another part of Switzerland, from M. Marquet, Engineer, formerly of the Ecole Centrale of Paris, and now Professor of Mathematics in the Special School of the Academy of Lausanne. The following is a translation of this document:—

ANSWER, so far as SWITZERLAND is concerned, to the QUERIES propounded by the INSTITUTION of CIVIL ENGINEERS of LONDON.

For the education of Engineers, there are two schools, the Federal Polytechnic School of Zurich, and the Special School for Industry, Public Works, Buildings and Arts, at Lausanne. The former was founded in 1854, the latter in 1853.

Before the establishment of these schools, the Engineers of Switzerland were educated either by practice in offices, or in workshops or building-yards, or by attending the Polytechnic Schools of France or Germany, or the Ecole Centrale of Paris.

Down to 1864, the Special School of Lausanne was a free school, founded and maintained by the sole efforts, intellectual and financial, of the five professors who had founded it. From 1864 to 1867, it has been aided by annual subscriptions amounting to a total of 12,000 francs; and since 1867, the State has granted an annual subsidy of 10,000 francs, and the City of Lausanne one of 2,000 francs. This school cannot go on with its own resources, as there are not sufficient scholars; it must soon become a school of the State.

The Federal Polytechnic School is a central establishment for which the Confederation pay annually 250,000 francs (furnished by the contributions of cantons). The City of Zurich, where it is established, contributes annually 16,000 francs, and furnishes besides the scientific collections, the forests for the School of Forest Economy, and the buildings where the instruction is given.

In these two schools the Government is represented by a certain number of members who form part of the directing council. For the special school one of the members of the municipality of the City of Lausanne has a seat at the council of administration.

Printed programmes, which may be procured on application to the directors, give all the details necessary for admission into the schools, as well as the nature of the instruction given.

The mode of instruction consists in lectures, repetitions, weekly examinations of the pupils, exercises in drawing (mechanical, architectural, &c.), and competitions proposed to the pupils in the form of designs to be studied or defended before the professors.

The courses are arranged by the professors, who lecture orally, making use of drawings on a large scale, either prepared beforehand or drawn with chalk on the black board in the presence of the scholars. Models of machines or apparatus are also laid before the students.

No books are put into the hands of the students which can supply the place of lectures; those which they may consult in the library are either special treatises on certain branches of Engineering art, or periodical publications on constructions, manufacturing industry, machinery, or architecture.

The students form their own courses of instruction, by preparing books from notes taken during the lecture.

The Federal Polytechnic School of Zurich gives the following diplomas:—

1st division. School of Construction (architecture and the art of building); diploma of Engineer Constructor.

2nd division. School of Civil Engineering (roads, bridges, railways, hydraulic works, surveying); diploma of Engineer of *Ponts et Chaussées;* diploma of Topographical Engineer.

3rd division. School of Machinery (industrial mechanics, manufactures); diploma of Mechanical Engineer.

4th division. School of Chemistry (industrial chemistry, pharmacy); diploma of Industrial Chemist; diploma of *Pharmacien.*

5th division. School of Forest Economy (agriculture, topography, construction of bridges, roads, and hydraulic works, &c., applicable to forests); diploma of Forest Engineer.

The Special School of Lausanne gives the following diplomas:—

1. Engineer-constructor (bridges, roads, railways, canals, harbours, rivers, and streams).
2. Engineer-chemist.
3. Architect.

There is still in Switzerland some education by apprenticeship to a practical engineer. But since the establishment of the schools mentioned above, it is generally preferred to obtain the diploma, and afterwards to gain experience as paid assistants in practical service. The writer has no means of obtaining information as to the duration of the apprenticeship or the fees paid.

In Switzerland any one is free to assume the title of Civil Engineer on his own responsibility without having passed through regular studies or being provided with any certificate or diploma. The law regulates the responsibility incurred by all those who undertake works for the State or for private individuals.

The public however give confidence in preference to those who have obtained diplomas in the public schools.

The writer recommends strongly a work on industrial education, prepared in France by a Commission consisting of General Morin, M. Perdonnet, and M. Mourrier. It is published by the *Imprimerie Imperiale*. 1865.

M. Kinkel, of Hirslanden, near Zurich, sends copies of the "Bibliothèque Industrielle et Revue Suisse," Nos. 115 and 116, (Lausanne, July and August, 1867,) in which are articles by Professor Botley, on the Federal Polytechnic School; these will also be found in the Library of the Institution.

The following additional information is communicated by Mr. R. Crawford, Assoc. Inst. C.E.

For entrance to the Polytechnic School of Zurich the following are necessary:—

1. A written statement containing the name and home of the candidate, the profession or calling for which he is to be prepared, as also the department and class he wishes to enter.
2. The written consent of his parents or guardians.
3. A certificate of age: as a rule, 17 (or for the 2nd class, 18,) is the standard.
4. A satisfactory certificate of moral character from competent civil authorities, or from the authorities of the last school at which he was.
5. Certificates as to the course of studies gone through up to that time, as also of his practical diligence, in the event of the candidate having previously been occupied in any calling.

Those candidates who have not strictly fulfilled the requirements for entrance stipulated in articles 7 and 8 of the Regulations, or who are not allowed to omit the entrance examination in consequence of possessing a certificate of fitness from a recognised school authority, have to pass an entrance examination at an appointed time, and to deposit at the office of the director some unassisted geometrical and perspective drawings.

Particulars as to the entrance examination will be made known by means of a notice posted up.

Entrance and Yearly Fees.

	Francs.	£.	s.	d.
Entrance fee	5	0	4	0
Yearly fees	100	4	0	0
Ditto Library fee	5	0	4	0

In case of attending the laboratories or workshops during the winter half year an additional charge is made of 30 francs (£1 4*s.*) for each of the chemical laboratories; 10 francs (8*s.*) for the metal workshops, and 5 francs (4*s.*) for the model workshops.

ENGINEERING SCHOOL (Three Years' Course).

First Year's Course.

Differential and integral calculus (with repetitions); descriptive geometry (with repetitions) and examples.

Study of the art of building.

Building drawings; plan drawing.

Second Year's Course.

Study of differential equations; differential and integral calculus (with repetitions).

Technical mechanics (and repetitions).

Plain geometry.

Study of shadows and perspective.

Topography.

Technical geology.

Technical physics (with repetitions).

Construction of machinery.

Third Year's Course.

Theoretical study of machinery.

Mechanics.

Theory of heat, and theory of the steam engine.

Construction of earthworks, bridges, and tunnels (with repetitions).

Examples in construction.

Construction of roads and canals.

Geodesy; plan drawing.

Astronomy; administrative law.

Theory of construction of iron roofs.

The manufacture of rolled iron and the strength and calculations for iron girders.

Further information as to the Federal Polytechnic School will be found at page 524 of the Replies to Lord Stanley's Circular, and at page 156 of the Translated Report of the French Commission.

School at Lausanne.

A very full account of this School will be found at page 516 of the Replies to Lord Stanley's Circular.

The object of the School is to form Civil Engineers, Mechanical Engineers, Chemical Engineers, and Architects. It is organised so as to afford to young men destined for any one of these professions all the theoretical and practical knowledge required. The studies extend over three years.

Full detailed programmes of the instruction are given.

All the courses are equally obligatory on the pupils whatever may be the special branch which they may have selected as their future vocation.

At the end of the third year the pupils pass a competitive examination for the purpose of obtaining a *diploma of Engineer.*

ITALY.

THE following is a translation of a memorandum furnished by Professor Sismondi, of Turin :

I. *On the General System of Instruction of Civil Engineers in Italy.*

Candidates for the diploma of Civil Engineer have to go through a course of mathematics in one of the Universities of the State having a faculty of physical and mathematical sciences.

This course occupies three years, and the students learn there algebra and analytical geometry, the differential and integral calculus, mechanics, descriptive geometry, theoretical geodesy, inorganic chemistry, physics and drawing.

In order to be admitted to this course, the young men must have passed the final examination of the ordinary schools (*Liceo*), and the examination of admission for the mathematical course.

After the termination of the course of the University there is an examination for each of the subjects studied, after passing which the student is admitted into the *School of Application.*

In this school the course lasts two years ; and the student studies there applied mechanics and practical hydraulics ; the construction of civil hydraulic works and of ways of communication ; chemistry, mineralogy, and geology, so far as interests the practical engineer ; agricultural economy, jurisprudence, and political economy, so far as concerns engineering ; practical architecture, surveying, especially topographical, mechanical and constructive drawing, &c.

There are two Mechanical Schools, having the special object of teaching all that relates to the steam-engine and to railways.

According to certain new regulations, not yet carried into effect, the Civil Engineers will attend lectures on industrial physics and mechanics.

When these courses are finished, and the examinations passed on each subject, the candidate is admitted to a special trial, after which he receives the diploma of Civil Engineer.

II. *Whether or not the Government intervenes, and the mode of its intervention.*

The University Schools, and the Schools of Application, are all at the charge of the Government, both as to the pay of the professors and as to the cost of the museum, laboratories, &c.

The School of Milan receives a part of its endowment from the city and from the society of local encouragement.

The students pay fifty francs for the admission-examination to the course of the University; one hundred francs per annum for each year of the mathematical course: one hundred francs per annum for each year of the course of application; and one hundred and twenty francs for the final examination.

They also bear some part of the reasonable expenses of the practical exercises.

III. The Schools of Application for engineers are:

That of Turin, founded in 1859, and opened the following year.

That of Milan, founded some years later.

That of Naples, which is an old School of Ponts et Chaussées, adapted to the model of the School of Turin.

In the Universities of Padua and Palermo there is added to the mathematical course a species of School of Application; the professors, however, are the same.

IV. With the present paper there are sent the programmes of the courses of the School of Application of Turin.

For the courses of architecture, mineralogy, practical geometry, and drawing, there are no programmes.

V. The instruction in the School of Turin is divided into two terms: the first is from the middle of November to the middle of May, and is both theoretical and practical; the second is from the middle of May to the end of August, and consists of practical exercises in the applications of the various sciences varied with scientific excursions.

There is sent herewith a list of the teachers, with the orde of their lectures, and the programme of the practical exercises.

No text books are adopted; the professors indicate to the students the works most accredited, which they then consult in the library of the school.

The Professor of Agricultural Economy has, however, published a treatise, appertaining chiefly to his own instruction. ("I primi elementi di economia e stima de' fondi rustici, etc., per Giuseppe Bazio." Torino, 1862. 8vo. 1 vol.)

The Professor of Mechanics and Hydraulics has also published a summary of the lectures given by him. ("Sunti e programmi delle lezioni di meccanica applicata e idraulica pratica, del Conte Professore Richelmy." Torino, 1863.)

The Professor of the Steam-engine and Railways, with the aid of some of his pupils, has also published—

1. An Atlas of Designs of Apparatus and Machines, serving as illustrations to his course. Torino, 1864.
2. A collection of plates for the same object.

VI. To the present time the School of Application at Turin has given the diploma of *Laureate Engineer*, which authorizes the holder to practise every branch of engineering.

According to the new rules of 1867 (not yet put in force) the school will grant special diplomas for—

1. Civil Engineers.
2. Engineers for mechanical industry.
3. Engineers for agricultural industry.
4. Engineers for chemical industry.
5. Engineers for metallurgical industry.
6. Civil Architects.

VII. In order to obtain this diploma, a University course of two years is necessary, followed by two years in the School of Application.

The subjects to be studied in each of the courses for the various classes of engineers are indicated in the rules.

VIII. Engineers provided with their diplomas are not required to have any further practice in order to be admitted to the exercise of their profession. The practice necessary is obtained by them in the second period of each of the two years of application. Consequently the persons bearing diplomas are authorized to undertake immediately any work appertaining to their profession.

The following publications accompanied the foregoing statement. They will be found in the library of the Institution, and refer to the "Scuola di applicazione per gli Ingegneri Laureati in Torino."

Programmes for the examinations in—

Applied Mechanics.
Chemistry.
Construction.
Steam-engine and Railways.

Legal subjects.
Rural Economy.

Also programmes of the arrangements and hours of the various studies.

Copies of the two royal decrees of 14th October, 1863, and 16th November, 1867, giving full and valuable particulars of the objects, arrangements, and regulations of the school.

SPAIN.

In regard to Spain, the following letter has been received from M. Montessino, of Bilbao, who has, at the request of Mr. C. Vignoles, President, taken much pains to collect the information required:

There are five different classes of Civil Engineers in Spain, exclusive of Military Engineers:

1st. Ingenieros de Caminos, Canales y Puertos. (Roads, canals, harbours.)
2nd. Ingenieros de Minas. (Mines.)
3rd. „ de Montes. (Forests.)
4th. „ Yndustriales { mecanicos. (Mechanical industry.)
  quimicos. (Chemical industry.)
5th. „ Agronomos. (Agriculture.)

I believe the inquiries of your Institution refer specially to the first, which are what the French call *Ingénieurs des Ponts et Chaussées,* but yet I have thought it best to send you the necessary information on all of them. You will find it in the books I forward, and which will reach you shortly after this letter. They are the following:

A. Coleccion legislativa de Minas, 1865.
B. Legislacion de Montes, 1866.
C. Legislacion de Agricultura, 1866.
D. Ley y Reglamento de la Enseñanza Agricola, 1867.
E. Anuario de la Instruccion Publica de 1867 a 1868.
F. Memoria de la Direccion General de Agricultura, Industria y Comercio en Octobre de 1861.

You will find all the information relative to *Ingenieros de Minas* in A; to those of *Montes* (Forests) in B; to the *Agronomos* (Agricultural) in C and D, and to the *Ingenieros Industriales* in E, pp. 412 to 414. In F are embodied matters referring to all of these.

G. Reglamento pura la Escuela especial de Ingenieros de Caminos, Canales y Puertos.
H. Programa de examenes de ingreso en la misma escuela.

I. *El Universal* de 24 de Octobre, 1868, in which is inserted a Decree modifying the matters henceforth to be taught in the different schools for Engineers, and also those on which the candidates for admission are to be examined. As much of what has been hitherto taught in the above schools is now required of the candidates on entering, the number of years of study has been reduced for the Engineers *de Caminos, Canales y Puertos* from six to four; for those of Mines to four also, and for the Engineers *de Montes* (Forests) to three.

K. Memoria de Obras Publicas de 1856.
L. „ „ de 1857 a 1859.
M. „ „ de 1859 a 1860.
N. „ „ de 1861 a 1863.
O. } „ „ de 1864 a 1866.
P. }

Q. Informe sobre la contabilidad del Ministerio de Fomento. (This ministerial department embraces public instruction, public works, agriculture, industry, and commerce.)

The Memoirs from K to Q are specially sent that your Institution may have certain knowledge of what has been done in public works in Spain, in the last thirty years particularly. In the first of the series, K, published by me as Director-General then of that department, you will find in Chapter VII., p. 149 to 172, an extensive notice of our Corps of Civil Engineers (*Ingenieros de Caminos, Canales y Puertos*) and its special school up to 1856. In Part O of the report relative to the years 1864, 65, and 66, particularly at p. 23 to 24, and in *El Universal* (I) are to be found the latest innovations relative to the *personnel* and to the school to which the programmes G and H refer.

In each branch of Engineering there is but one school for the training of Engineers, and generally also but one for their respective assistants.

All of them are maintained at the public expense, the students paying nothing (the *Ingenieros Industriales* excepted, for they pay a small yearly fee as being under the University rule). Those, however, who ask for a diploma on finishing the whole course of their studies have to pay £10 for it.

At the expiration of the fourth year at the schools of the three first classes of Engineers, the students, after examination, were, until lately, promoted to the rank of *Aspirantes* of the respective corps, and received from Government £60 each yearly for the next two years; then they, after a final examination, entered the corps; but now neither are they to receive any pay the last two years of school, nor is their ingress into the corps sure, as they are only admitted to fill up vacancies.

Those that have no place in the corps organised by Government for the service of the State, work as Engineers for private parties or companies, their diplomas giving them no privilege, as anyone, Spaniard or foreigner, with or without a title or diploma, can exercise in Spain the profession of an Engineer, which is perfectly free. The diploma is only considered as a pledge of sufficiency.

This system has hitherto produced the most beneficial effects, as the extent and nature of the public works executed in the last twenty years testify. It has also contributed wonderfully to propagate the study of the exact and physical sciences, formerly completely neglected amongst us.

The practice, as in England, of serving a regular pupilage to a practising Engineer is not followed here. After completing their studies, the young Engineers generally find remunerative employment as assistants under their seniors.

You will see at pp. 91 and 101 of the Report O that the expenses of the School of the *Ingenieros de Caminos, Canales y Puertos* were for the scholastical year, 1865-66, the following:—

	Reals.
Professors and all other *personnel* . .	162,138
Materiel	129,077
Total, say £3,065 . . .	291,215

CIPRIANO SEG. MONTESSINO.

Other communications from M. Montessino give further particulars as to the cost to the State of the various schools, and the textbooks used in the different branches of scientific education carried on therein.

The books mentioned in the foregoing communication are in the Library of the Institution; and to them are added the following:—

"Escuela especial de Ingenieros de Caminos, Canales y Puertos. Programos de las asignaturas que comprende la enseñanza. Madrid, 1868." (Special School of Engineers of roads, canals, and harbours. Programmes of the courses of study.)

"Suplemento a la revista de Obras Publicas. Coleccion de leyes, decretos, ordenes, reglamentos, e instrucciones relativos al ramo de Obras Publicas. Madrid, 1856." (Collection of laws, decrees, regulations, &c., relative to public works.)

"Reglamento Organico del Cuerpo de Ingenieros de Caminos, Canales y Puertos; aprobado por Real Decreto de 28 de Octobre de 1863. Madrid, 1864." (Regulations for the organization of the corps of Engineers of roads, canals, and harbours; approve by Royal Decree the 28th October, 1863.)

AMERICA.

UNITED STATES.

INFORMATION respecting the engineering education in the United States is contained in several letters, the substance of which is given in the following extracts.

Mr. Benj. Smith Lyman, of Philadelphia, gives the following remarks:

The general system of Engineering education is in America carried on in so-called "Scientific Schools," or "Institutes," wholly without Government support. These schools give diplomas to those who pass their examinations, but our laws do not require any such diploma before a man may practise as an engineer. Some of the principal Engineering schools are the Rensellaer Polytechnic Institute at Troy, New York; the Lawrence Scientific School, and the School of Mining and Practical Geology, both of Harvard University, Cambridge, Massachusetts; the Sheffield Scientific School, of Yale University, Newhaven, Connecticut; the Columbia School of Mines, New York City; the Technological Institute, Boston, Massachusetts. At most of these schools, or at all of them, other students besides Engineering students are taught. Many engineers have never studied at these schools but have gained their knowledge by serving with a practising engineer, and this was especially true in former years. I know nothing of the fees in such cases: but imagine there are none in general, but that the learner is paid for his services in proportion to their value, little or nothing at first and more afterwards. Anybody in this country is as free to assume "the style and title of Civil" or "Mining" Engineer as he is to take that of blacksmith, and it is still done commonly without any regard to school diplomas.

Mr. A. C. Morton writes as follows:

There is no institution of education, established and supported by the Government of the United States, except the West Point Military Academy in the State of New York.

Although the object of this institution is the military education of young men desirous of entering the army, yet, in the thorough course of military studies and training through which the cadets pass, is included the general principles of Civil Engineering; and many of the graduates of this institution have from time to time resigned their appointment in the army, and have not only become distinguished Civil Engineers, but distinguished in other professions.

As a general rule, the Civil Engineers of the United States received their education at the various colleges and academies of the country, which in most cases have no special reference to engineering. In a few instances Professorships in Engineering have been established in some of the colleges of the United States, and several academies and schools have been established which give special prominence to those branches of education which qualify young men to become Civil Engineers, and in some instances embrace the use of instruments and field practice.

There is no system of pupilage in the United States, as in England, neither is there required any examination diploma or certificate to enable a man to enter and practise the profession of Civil Engineer. He is usually thoroughly prepared by a good mathematical education, and acquires his profession by long experience in the practice of engineering—passing through all the grades and subordinate duties until he attains a somewhat prominent position, and becomes well known to authorities or corporations seeking the services of an Engineer, when, if he possesses the confidence of such parties, he receives the appointment of Chief Engineer.

From the commencement of his services, and in all the subordinate grades through which he passes, he receives pay for his services, which at first is moderate—only sufficient to defray his personal expenses; but his pay is increased as he advances in his profession and becomes useful to his employers. The length of service before he attains the position of Resident, or Chief Engineer, depends mainly on the talent, the energy, and enterprise of the individual, although he is often aided by adventitious circumstances in his advancement. Without this preparation and experience he is not recognized as a Civil Engineer, and does not usually attain to a responsible position in the exercise of his profession.

Works have been prepared which are used as text-books in engineering education by Professors Mahon and Davies, of West Point Military Academy, and by Professor Gillispie, of Union College.

The Government of the United States appoint annually a committee of inspection, which committee devotes several days to the examination of the management and efficiency of the system of education pursued at the West Point Military Academy, and report the result of their examination to Government, which report is published, and usually regarded as an interesting and important document.

The following is from General Francis H. Smith, Superintendent of the Royal Military Institute at Virginia:

I would premise my specific answer to the questions proposed, by stating that, in the earlier stages of engineering education in this country, the graduates of the United States Military Academy at West Point constituted the chief supply for the profession. The programme of studies at West Point essentially corresponded with that of the Polytechnic school of Paris, and of the applied schools in association with it, and thus really presented, at the time, the best outline of a course of education for a Civil Engineer to be found in this country. Scientific institutions have sprung up very rapidly in the last twenty-five years, and now other establishments are to be found which supply a high grade of engineering education.

The Virginia Military Institute is a State institution; that is, it was established and is supported by the State of Virginia. It was modelled upon the system prevailing at West Point, and has thus supplied to the Southern States the chief engineering education demanded by them, and numbers among its graduates such names as Mahone, Rodes, Rives, Jordan, Wharton, Rumbough and others, who have occupied distinguished positions as Civil Engineers on the various works of engineering in the South. The West Point course was in some respects modified to meet this specific purpose, and the modification has been continued each year with distinct references to the wants of a *civil*, rather than a *military* education.

With these preliminary remarks, I proceed to answer, *seriatim*, the questions propounded:

I. The preliminary training consists in a thorough course of Mathematics, Mechanics, Optics, Astronomy, Acoustics, Chemistry, Physics, Mineralogy, Geology, Physical Geography, Descriptive Geography, English, Latin, French, Drawing (industrial, topography, and human figure), Rhetoric, Logic, Moral Science.

II. Besides being required to stand an approved examination in all the branches embraced in No. 1, the pupil is also required to pass an approved examination in a full course of Civil Engineering, theoretic as well as practical, as exhibited in the programme of the course of studies herewith communicated, and also in a course of military education, ordnance, and tactics.

III. No one receives a certificate from this Institution, except that of graduate. This degree, in the Academic School, is not specifically a degree as a Civil Engineer, but the graduate is prepared, by the general courses of study, to enter the profession at a low point, and is as well fitted for the profession as a graduate of West Point. In America, each man takes a profession as he pleases, without let or hindrance by legal disqualification for incompetence; and thus, except among professional men, the degree of Civil Engineer has not, in past years, been a necessary passport to the profession.

The establishment of scientific institutions of a high grade in the United States, within the last fifteen or twenty years, has tended to improve the course of Engineering education; and the consequent improvement in the profession has induced the Institution to extend its course of education, by the introduction of a Special School for Civil Engineering and Mining Engineering, in which schools the degrees of Civil Engineer and Mining Engineer are awarded to all who complete the prescribed course. This course is indicated in the accompanying programme of studies; and it is expected that those who receive either of these special degrees will be qualified to enter the profession of Civil Engineering or Mining Engineering, with advantages at least equal to those of any institution in America. At present, the Special School of Mining Engineers embraces young men who have already graduated at the Academic School, and who expect to devote two years to the Special School. The provision made for the instruction will be seen to be ample, inasmuch as we have one professor of Civil Engineering and applied mechanics, one professor of Practical Engineering and drawing, one professor of general and applied chemistry, one professor of geology, mineralogy, and metallurgy, two professors of physics, in the Special School.

IV. The Government affords no aid to the profession.

V. All the colleges and universities profess to give a course of Engineering.

VI. Sundry documents are sent as requested.

General Smith's letter is accompanied by several documents, giving more detailed information as to the Institute under his direction.

General Robert E. Lee, President of the Washington College, Virginia, sends a "Catalogue" or Prospectus of this Institution, the following extract from which will give an idea of the course of Engineering professed there:

CIVIL AND MINING ENGINEERING.

In addition to the usual Literary and Scientific courses, the Schools are so arranged as to embrace full courses in—

I. Civil Engineering (*including Mechanical and Topographical Engineering and Architecture*).

This course extends over three years, and those students desiring to enter it must have previously completed a course in Algebra, Plane Geometry and Trigonometry, and must possess a proper knowledge of the English language.

It may be divided as follows:

First Year.

Pure Mathematics. *Intermediate Class*	**Prof. Nelson.**
Chemistry	**„ Campbell.**
Drawing, Industrial and Topographical	**„ McCulloh.**
Civil Engineering. *Junior Class*	**„ Allan.**
French	**„ Joynes.**
English	**„ Johnston.**

Second Year.

Pure Mathematics. *Senior Class*	Prof. Nelson.
General Physics	„ McCulloh.
Civil Engineering. *Intermediate Class*	„ Allan.
Astronomy	„ „
Rational and Applied Mechanics (*commenced*)	„ McCulloh.

Third Year.

Civil Engineering. *Senior Class*	Prof. Allan.
Mineralogy and Geology	„ Campbell.
Rational and Applied Mechanics (*completed*)	„ McCulloh.

II. Mining Engineering (*including Chemical Analysis, Geology and Metallurgy*).

First Year.

Same as in preceding course.

Second Year.

Pure Mathematics. *Senior Class*	Prof. Nelson.
General Physics	„ McCulloh.
Civil Engineering. *Intermediate Class*	„ Allan.
Rational and Applied Mechanics	„ McCulloh
German	„ Joynes.

Third Year.

Analytical Chemistry	Prof. Campbell.
Mineralogy and Geology	„ „
Tunnels, Shafts, Arches, &c.	„ Allan.
Applied Physics	„ McCulloh.

Diplomas will be awarded to students in these courses who pass a satisfactory examination, and submit such plans, drawings, specifications, calculations, &c., on some subject or subjects, as may prove their ability to take charge of and direct professional work.

Mr. Zerah Colburn, a good authority on the subject, writes as follows:

Young engineers acquire their professional education in the States much as they do here, by serving as assistants to engineers in practice. As assistants they are paid what they are worth, and if they were not worth paying no engineer would have them, for I never heard of the premium system in the States, and am well-nigh certain it does not exist there. A young engineer can set up for himself as soon as he can find any one to employ him, and style himself "C. E.," if he likes, the same as here. There is no support of engineering education either by the national or State Governments. Civil Engineering is taught, to a greater or less extent (in connection with mathematics and physics), at the Lawrence Scientific School, in connection with Harvard University; Cambridge, near Boston, Massachusetts, at Brown University; Providence, Rhode Island, at the Rensselaer Polytechnic School; Troy, State of New York, at Union College; Schenectady, New York, at Columbia College; New York (city); at the Pennsylvania Polytechnic College, Philadelphia, and possibly at one or two other places. The Franklin Institute once had Polytechnic Classes. I regret that I am unable to supply any list of the studies, further than that they relate to engineering.

Generally, I should say, the "system" of qualifying engineers in the States is much the same as qualifying merchants, steam-boat proprietors, railroad managers, &c. Those take to it who like, and the best young men work up to it and get on. This may appear very unsatisfactory, but I think it is not very wide of the truth.

CANADA.

THE only information as regards Engineering education in Canada is contained in a letter from Dr. J. M. Dawson, F.R.S., Principal and Vice-Chancellor of M'Gill University, Montreal. He states that in that university a course of Engineering was established in 1857, and was continued for several years, but was suspended in 1864 by reason of the deficiency of funds, the failure of attempts to obtain public aid, and the then depressed state of the profession.

Dr. Dawson is not aware that anything has been done in regard to Engineering education in Lower Canada, either by the Government, or by any educational body, other than the attempt above named.

PART III.

SUGGESTIONS
MADE TO THE COUNCIL BY VARIOUS PERSONS,
AND
EXTRACTS TAKEN FROM VARIOUS PUBLICATIONS
BEARING ON THE SUBJECT OF
ENGINEERING EDUCATION GENERALLY.

In addition to the information contained in the foregoing parts, suggestions on the subject of Engineering Education generally have been kindly offered to the Council by several professional gentlemen whose opinions are deserving of respect, and their communications are printed in the following pages.

To these it has been thought desirable to add some extracts from published documents in which the subject of Engineering Education has been treated of more or less fully.

SUGGESTIONS OFFERED TO THE COUNCIL ON THE SUBJECT OF ENGINEERING EDUCATION.

From Sir John Rennie, F.R.S.

Education of a Civil Engineer.

Any person intended for the profession of a Civil Engineer, in my opinion, should be educated as follows: In the first place, he should be sent to some good school until about twelve years of age, where he may be thoroughly grounded in reading, writing, composition, arithmetic, algebra, geometry, English, Latin, and Greek grammar. I mention the two latter as it will enable him hereafter to acquire with facility European or other languages as occasion may require, particularly French, German, Italian, Spanish, &c.

From about twelve to sixteen he should be sent to one of the junior universities, such as King's College, the London, Edinburgh, Glasgow, or Dublin Universities: here he should attend the different classes of mathematics, algebra, geometry, plane and spherical, trigonometry, astronomy, natural philosophy, geology, geography, chemistry, electricity, and drawing, assisted by private tutors, who, by frequent examinations, should make him thoroughly understand what he has learned, and enable him to pass with credit the several public examinations which he must undergo.

At the age of sixteen, if he has been *diligent* and *well looked* after, he ought to have obtained a sound general education, particularly as regards the scientific department connected with the profession of a Civil Engineer.

At sixteen he should be apprenticed to some practical manufacturing Engineer of eminence, where he should commence working with his hands, and go through all the departments of pattern-making, founding, turning, fitting and erecting steam-engines, marine, locomotive, and fixed, and all the variety of machinery connected with them and railways, and a general knowledge of ship-building, whether of iron or wood, also the mechanical drawing and calculating departments connected with them.

After having been well employed in this manner for three or four years, combined with his previous education, he ought to be well versed or grounded at least in mechanical Engineering, which forms one of the most important parts of the education of a Civil Engineer.

Having completed this he should be sent to some good scientific and practical nautical and land surveyor for a short time, where, if diligent, he will soon be able to acquire a knowledge of levelling, laying out lines of roads, railways, canals, drainage, and mapping large districts of country and sea coasts.

He should then study practical hydraulics upon a great scale, such as the principles and management of rivers, embanking, draining, sewage, water supply, irrigation, the planning and construction of harbours, docks, bridges lighthouses, masonry, carpentry, earthwork, &c., with a thorough knowledge of the use and best mode of applying materials of all kinds; and having previously obtained a knowledge of working iron and timber, he should do the same with stone, cements and other materials. He should likewise practise himself in drawing up detached reports, plans, specifications, and estimates of the various works. In these departments he will be greatly assisted by reading and carefully studying the reports and plans of Smeaton, Telford, Stephenson, Brunel, Watt, Rennie, and other eminent Engineers.

He should also study architecture, so as to be able to design and construct all the buildings connected with Civil Engineering such as railway stations, sheds, and warehouses.

Public buildings and ornamental architecture, strictly speaking, are rather out of his line; nevertheless, if he has time and taste for it, he can do so at his leisure.

With regard to languages, it certainly is desirable that an Engineer should know well German, French, and Italian; having previously laid the foundation of them he can easily acquire them at his leisure.

With regard to the higher classes of physics and mathematics, these, although not absolutely necessary for the practice of Civil Engineering, still, no doubt, they form a most valuable accomplishment for those who have time and taste to acquire them. With regard to the honours conferred by purely scientific societies, they are open to any one who chooses to qualify himself for them, and desires them; and if either his executed works or writings are worthy of these distinctions, he will have no difficulty in obtaining them.

After a candidate for Civil Engineering has creditably gone through the above education, he will have arrived at about the age of twenty-three or twenty-four years; he may then confidently present himself to any Engineer in large practise as an assistant at an adequate salary, or he may practice upon his own account; but he must always bear steadily in mind, *that nothing but constant industry and hard work, combined with a thorough* *determination to overcome all obstacles* in his progress, can make him a good Engineer. I should not recommend Eton, Harrow, Oxford, or Cambridge; they may do for the law, medicine, or the Church, not for the Engineer.

The above course of education appears to me the best adapted for a Civil Engineer, and if the candidate will only pursue it zealously and steadily he may in time become a credit to the profession.

JOHN RENNIE.

5th August, 1868.

FROM MR. HENRY CONYBEARE.

James Forrest, Esq., Secretary,
Institution of Civil Engineers.

20, Duke Street, Westminster, S.W.
23rd August, 1868.

DEAR SIR,

I regret that my answer to your letter on the subject of professional education should have been so long delayed.

I gave a good deal of attention to the subject about twelve years ago, and stated my views thereon in the inaugural address to the course of lectures I delivered at Woolwich, in 1857, to the junior officers of the Corps of Royal Engineers, on the principles and practice of Civil Engineering, and I presented a copy of this address, and of the first four lectures of the course, to the library of the Institution.

At that time my impression—as far as I had an opportunity of forming an opinion—of the respective results of the Engineering education of the Continent and of this country was, that foreign Engineers were usually wanting in practical experience, and our own in scientific training.

But I think that this is no longer the case, for the large amount of work that has been executed in France during the last decade has afforded to the French Engineers opportunities (*of which their previous scientific training enabled them to avail themselves to the utmost*) of acquiring the practical experience in which they had been before wanting, while I fear that the scientific training of English Engineers is usually just as defective at the present time as it was twelve or even twenty years ago.

I think that no Engineer, who made the engineering models in the late French Exhibition the subject of a really attentive study, especially if he had the advantage of being accompanied over them day after day by Engineers of the Ponts et Chaussées, could fail to have been struck with the practical skill as well as with the science they displayed, and no less so with the admirable clearness and precision (resulting from their thorough scientific training) with which the French Engineers who accompanied him explained the principle and motive of any novelty in their design or modes of construction.

It is obvious to ourselves, and indeed notorious even to outsiders, that the two leading defects of our system are as follows: First, that we have no real professional organization, and secondly, that the mere fact of any one being elected a member of the Institution is no more evidence that he possesses any of the qualifications of a Civil Engineer, than the fact of a man being called to the bar is a proof of his knowing anything of laws; the only essential qualifications being, in the one case, that the candidate should have kicked his heels for three years in an Engineer's office, and in the other, that he should have eaten, or sat out, a certain number of very bad dinners.

I feel great diffidence in offering an opinion on such a subject, but it does seem to me that the Council of the Institution have it in their power to remedy both these defects in very great measure, if not entirely, and that by merely building on existing foundations.

I think they might make their influence felt with great effect, first, on the improvement of mathematical teaching in schools generally. I noted the existing defects in this particular, and advocated the substitution, as far as possible, of applied mathematics for pure mathematics, in a note that will be found at page 15 of my inaugural address; and I observe that Mr. Lowe has urged the same thing very strongly in one of his late speeches on education, which has been published as a pamphlet. The Council might bring great influence to bear in the same direction.

Secondly, I think that by manifesting a special and continuing interest in the Engineering departments of King's College in London, and in those of the Queen's College in Ireland, by offering prizes to their students, and by nominating examiners on practical Engineering for their periodical examination, and by arranging that one of themselves should belong to the Council of King's College, they might very soon acquire a controlling influence over these Engineering schools, and thereby give a more effective and practical direction to the education they afford, and at the same time in some measure affiliate these professional schools to the Institution.

It is obvious that such a result would conduce very greatly to an effective organization of our profession, for the Institution would thus make its influence felt from the very commencement of Engineering studentship, and would thus greatly extend *its basis,* and become, very much more than it is at present, the centre to which all connected with Engineering would gravitate.

Thirdly, there would be then only one thing required to complete the organization of the profession, namely, that the Council should make it a rule that no member of the Institution should take a pupil who had not obtained from the Engineering department, either of King's College or of one of the Queen's Colleges in Ireland, or from a Board of Education appointed by one of them, a certificate of *adequate* proficiency.

It seems to me that such a rule would be so very obviously beneficial to every one of the parties concerned that there could be no difficulty in carrying it out. A parent who pays a premium of £500 to obtain for his son the advantages derived from a three years' pupilage in an Engineer's office, naturally desires that he should avail himself to the utmost of the advantages that he has so placed within his reach. and without previous scientific and engineering training this is absolutely impossible.[1]

To the Engineer who received the pupil into his office the advantage of such a rule would be even greater: a pupil who knows nothing of Engineering is only in the way in an office, and often not only does no good himself, but interferes with the work of others; whereas one who has passed through any of the Engineering schools I have mentioned is able to take his place at once as a useful, if not an altogether efficient assistant, in the office or in the field. I speak from experience, for I have had four pupils who had gone through this preliminary training, and I found them serviceable assistants from the moment they joined me. And I knew of three *élèves* of the Engineering Department of Queen's College at Cork who, without any further pupilage, at once obtained well-salaried situations as Assistant Engineers. Two of them were so employed on the London, Chatham, and Dover Railway. I was informed that they gave every satisfaction, and from my own experience in pupils similarly trained, I can fully believe it. It was, of course, a grievous mistake on the part of their friends to omit the term of pupilage so essential to their future prospects; but the fact of their proficiency proves the great advantage of the preliminary training afforded by these Engineering schools.

And such an arrangement, by rendering it obligatory that every member of the Institution should have had scientific training, as well as experience in an Engineering office, and on Engineering works, would obviously tend to raise the standard of professional attainment and efficiency.

Fourthly, within the limits of his profession an Engineer should not only know "everything of something," but also "something of everything," and the "home circuit" is so crowded that leading Engineers take very much to special lines of practice, which renders it sometimes difficult for their pupils to become practically acquainted with some of the branches they may be called upon to practise in after life, in India or the colonies, for example.

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[1] This is stated more fully in pages 12—17 of my inaugural address.

It would, therefore, greatly conduce to the completeness of our system of Engineering education, if some arrangement could be organised under the auspices of the Council, whereby members of the Institution who practically confine themselves to special lines of practice (such as railway engineering, mechanical engineering, or water-works) could effect a temporary exchange of pupils towards the end of the term of pupilage—for example, it would greatly benefit the pupil of a water-work Engineer to spend three months in a fustian jacket in an engine factory, and three months more on railway surveys and works.

A really complete Engineering education occupies so many years that it becomes a most important question whether nothing could be done to shorten it, without sacrificing efficiency, and it seems to me that there are some practicable means of acceleration that would greatly conduce to such an end, and that the first of these is the improvement that has been suggested in the mathematical teaching of public and other schools, by which the pupil might be enabled to save half a year in the Engineering College course which follows.

I have said at "public schools," because I am convinced that in all callings it is an immense advantage in after life to have enjoyed the life training and the connection that can only be obtained in the same perfection by such schools as Eton, Rugby, and Harrow, and this, it seems to me, is of special importance in the case of Engineers, because their professional training begins too early to allow of their going to the University. It is a very material advantage to an Engineer to have been at a great public school till fifteen and a half or sixteen—by that age a sharp boy will be in the sixth or highest form of the school, and know as much classics as would enable him to take a degree at Oxford, and more than enough to enable him to pass at Cambridge. The great advantage of a public school education to an Engineer is not that if he gets into Parliament in after life he may venture upon a quotation without being laughed at for false quantities (though that is really something), but because through the connection of a public school, kept alive by the periodical reunions of his "school dinners," he will find schoolfellows on every Parliamentary Committee, and among every batch of squires whose land he wants for any new line of railway upon which he may be engaged, and such personal acquaintance, and knowing something of who you are *dealing with*, always facilitates the despatch of business.

It would be also advantageous if on passing a matriculation examination, that proved him up to the standard, a lad might be allowed to enter the Engineering Department of King's College at fifteen or fifteen and a half instead of sixteen; also if lads cleverer or more forward than their fellows might be allowed to be examined for the "certificate of proficiency" after two years instead of three, for it seems to me desirable that an Engineer's education should be completed at twenty-two, if not at twenty-one, and that it should include, besides the scientific training in an Engineering College, a three years' pupilage, of which six months should be spent in an engine factory.

I am,
Dear Sir,
Faithfully yours,
H. CONYBEARE.

FROM MR. GEORGE GILES.

The great works carried out in France during the last fifteen or twenty years show, I think, a satisfactory result of the education of Engineers in that country; but it has, nevertheless, great drawbacks; for as the Polytechnic School enjoys a monopoly in appointments, there is very little scope indeed for talented Engineers who do not belong to the Polytechnic Corps. I have known several gentlemen during my own operations in France who were eminently qualified, but who could not succeed as they deserved, not being Polytechnic scholars.

Looking to results, in the design and execution of works, I am bound to say also that the Engineers of *Wurtemberg* and *Baden* appear to me to take a very high standing; I should, however, regret giving the schools alone credit for these results; it may possibly be due to a development of great talent in the class I am alluding to.

FROM MR. J. M. HEPPEL.

James Forrest, Esq., Secretary,
Institution of Civil Engineers.

MY DEAR SIR,

In compliance with the wish of the Committee on Engineering Education, expressed in your letter of the 21st, I will now endeavour to state briefly my views in reference to that subject.

What seems to lie at the root of the question is to define the character and extent of knowledge which it is desirable a young

Engineer should possess previous to entering on the regular and responsible practice of his profession. On such a subject no doubt much diversity of opinion will be found to prevail, as well as on the best modes of acquiring such knowledge as is by general consent admitted to be requisite. I take it that I shall best meet the wishes of the Committee by a simple statement of my own view.

To begin with, I think it extremely desirable that the young Engineer should possess all the ordinary acquirements of a well-educated gentleman. He should be a moderately fair classical scholar, and should understand French and German, and if also Italian and Spanish so much the better. In English, besides a fair acquaintance with history and general literature, he should be master of composition so far as to express himself in speaking or writing with precision and force. Coming now to what may be considered more special, he should have a sound knowledge of common geometry, so much of trigonometry and conic sections as is usefully applicable in practice, of arithmetic, the nature and use of logarithms, of ordinary algebra, and of the higher analysis, so far as the general principles and most usual applications of the differential and integral calculus, a complete acquaintance with the theory of statics, and so much at least of dynamics as will enable him fully to understand any ordinary treatise on the action of the chief motive powers, as gravity, water, or the various forms of heat. He should be fairly acquainted with chemistry, geology, physical geography, and most of those branches of science which are commonly grouped together under the name of natural philosophy.

Even yet we have come to nothing which may be said to belong to the special training of an Engineer, being rather acquirements which would be desirable and useful to most persons, and which are more or less possessed both by private gentlemen and members of other professions: those which follow have more special application.

The young Engineer should have a good practical acquaintance with the mechanical properties of the principal materials of construction, and a sufficient knowledge of the trades of a carpenter, smith, millwright, bricklayer, and mason, to be a competent judge of their products. He should be a good mechanical draughtsman, and able to sketch and design clearly by hand.

He should have a thorough practical acquaintance with surveying, with the setting out of works from plans and levelling, and with the construction and adjustment of all instruments used in these operations. He should be expert in taking out quantities from plans and framing estimates, and be a sufficiently good accountant to fully understand and control accounts of expenditure in works.

Lastly, he should, both by reading and observation, and, if possible, by actual charge and responsibility, have collected a good body of knowledge of the best practice at home and abroad in executing important and difficult works.

The list appears long, but I doubt if it is by any means complete. I think, however, with these attainments, or a good proportion of them, we should have the making of a very fair Engineer, and this is all that can be expected from education; the rest must follow from the genius, perseverance, opportunities, and good fortune of the individual.

Looking now back to my list, I think it will be apparent that all the literary, mathematical, and purely theoretical matter, including some knowledge of chemistry, geology, geography, and natural philosophy, would be easily acquired by a boy of fair abilities at a public school in five years (say from ten or eleven to fifteen or sixteen), followed by one or two years' attendance on lectures at University or King's Colleges. At least so much would be acquired that the rest might easily be made up by private study concurrently with the subsequent pursuit of the more practical part.

Mechanical drawing should also, if possible, have been to a certain extent acquired during this period, but if not, a short time should be given to it specially, including the making of accurate and detailed sketches, with dimensions of machinery and works, and then drawing them to scale. As soon as the pupil has attained to some degree of proficiency in this, he should give from one to two years to the learning of some mechanical trade, amongst which I should prefer those of a smith or millwright: he should work full hours with the men, and as soon as possible earn wages.

The order in which the rest of the subjects I have mentioned are acquired does not strike me as very important, and the pupil might profit by the best opportunities. They might, as it seems to me, all be learnt in the office of an Engineer, always supposing two things; first, that his practice is sufficiently extensive; next, that the efficient education of the pupil, and not the mere utilization of him, is steadily kept in view. No doubt there are objections. The office of an Engineer is not, and probably cannot be made, an educational establishment. In the first place, he has too much personal occupation to be able to attend much to pupils; and in the next place, where work has to be got through, a pupil will inevitably be more or less kept to what is most pressing, or what he can do best. But supposing the most conscientious regard to be paid to his interests, even with the most extensive practice, opportunities must be waited for, whilst in a more restricted one they may be entirely wanting.

It is chiefly this latter class of considerations which lead me to insist on so much preliminary knowledge before entering an Engineer's office. A young man thus fortified would be very differently circumstanced from a boy just taken from school, and would probably find few things intrusted to him, however unpromising, from which information and improvement could not be derived. He would himself understand his own wants, and would not allow opportunities to be lost simply from inability to understand and appreciate them. Some might be more fortunate than others in the extent and variety of subjects presented to them; but I think, with moderately fair treatment, very few could fail in the course of three or four years to obtain such a body of information as would enable them to evince their capacity for responsible charge of works.

Leaving now for a moment this plan, which is the one usually followed more or less in this country, let us consider another, partially adopted here, but much more extensively on the Continent —that of colleges or complete establishments for the training of Civil Engineers. As far as the purely scientific and literary part of the course goes, there seems to be no reason why such a college should not impart as sound and complete instruction as any similar institution, supposing always the basis of a single profession to be sufficient to maintain it on a satisfactory scale; but then for this alone a separate establishment seems hardly requisite, as there appears to be nothing but what can be supplied by existing schools and colleges, and supplied, as it seems to me, if the courses are properly selected, so as to give full occupation to the student in the acquisition of what he really requires without superaddition of redundant or superfluous matter. If we look, however, beyond this to the more special training, I think some marked disadvantages, as compared with the former plan, will become apparent.

The work is not real work. The plan of the bridge may be neatly and carefully drawn, its strength calculated, its cost estimated; and all this may be submitted to judicious criticism, but nobody has got to build it. A survey may be made of the neighbourhood of the institution, or of a line of road or farm in its vicinity, and nicely plotted, but it has not got to pass a Committee on Standing Orders. A line of canal may be laid out and levelled, and a working section and detailed plans prepared, but it is exempt from verification by that most uncompromising examiner—water.

I do not at all mean to deny that even in these practical branches much useful information might be acquired, and the advantage of being able to instruct in classes and of selecting the order of subjects is obvious; but I do think that this kind of instruction cannot obviate the necessity of a subsequent probation in a real office and in actual work; and in many cases it might possibly have been there acquired as rapidly and certainly more completely.

In my point of view, then, the question is brought within a very narrow compass. The Engineer's education should begin at a good *school, best* at a public one. Following this should come a college course, more or less prolonged. He should then master some mechanical trade, or the order of the two last might, if more convenient, be inverted, and should, in any case, finish with a certain term of pupilage under a practising Engineer.

The question for which no precise rule can be laid down, as it depends on varying circumstances, is how much of his knowledge he should seek at college and how much under a master. No doubt all that he gets at college, including practical Engineering, as taught in the classes of King's and University Colleges, will be very useful, and place him in a more advantageous footing in any office he may enter. The point is to remember that it cannot take the place of the office work, and to see that time is not uselessly spent in the study of that which might have been better learnt in the office itself.

There is a matter intimately connected with the foregoing, on which perhaps a few words may be said; that is, the expediency of providing means of furnishing some diploma or certificate of proficiency to students who have passed their curriculum with credit and success.

I will not enter on the question of making our profession a close one, such as the bar, as, even if desirable (which I greatly doubt), too many practical difficulties suggest themselves; but I think that a man who may have worked steadily for six or seven years to master a certain standard of attainments is entitled to have some unquestionable mark granted him to distinguish him from those who have not.

I think also that the very defining of such a standard would probably do much to obviate some of the objections to pupilage under Engineers to which I have referred. If such a standard existed, and if, as a rule, pupils presented themselves for examination, I believe Engineers would necessarily become more particular in satisfying themselves of the preliminary attainments of proposed pupils, and in seeing their way clearly to supplement these to the required extent, and more attention than at present would be given to the pupil's progress and ultimate success, or he would be altogether declined.

What I would venture to suggest is little more than an extension of what has been already commenced at the universities of Oxford and Cambridge, where the principle of admitting persons who have studied elsewhere to examination for certain special degrees or certificates has been recognised and carried into effect.

Suppose a faculty of Engineering were created at one or more of our universities, not for educational purposes, but solely for examination, with power to define the subjects and appoint examiners, scientific and practical, not necessarily all members of their own body, and to confer some distinct degree, for instance, "Master in Engineering," on those who might fulfil the requisite conditions.

I think such a distinction would be fairly earned and duly appreciated, and would in no way trench on the legitimate status or rights of existing members of the profession, or on those of future members who might elect to dispense with it. As a simple certificate of actual attainment, it could not, I think, be objected to, and if it became substantially valuable, it would only be in consequence of its being found to be a real indication of capacity and trustworthiness.

This is not altogether new, for in the University of Madras, of the Senate of which I had for some time the honour to be a member, such a degree existed, and I believe it still exists, and is there much prized.

In conclusion, I would beg to submit to the Committee, that seeing the strong tendency now manifested by Government to take direct action in public works, especially in India, they might possibly be induced by a proper representation to take part by a Commission or otherwise in this inquiry, with the object of determining the best means of providing and maintaining a supply of well-qualified Civil Engineers for the service of Government or for employment in private enterprise.

I am, my dear Sir,
Yours very faithfully,
J. M. Heppel.

2, Storey's Gate, July 30, 1869.

P.S. In the foregoing I have confined myself to the consideration of such means as are at present available, or might easily be organised, under existing circumstances; but if these should become altered in a way which now seems not unlikely, probably a third plan of education might arise possessing certain advantages over either of those I have noticed. In the event to which reference has been made, of Government taking into its own hands, chiefly or entirely, the construction of public works in India, it seems evident that they will require the services of a large permanent staff of Engineers: without expressing any opinion on the policy of this, it would evidently open a new means of completing an Engineer's education, inasmuch as the period of pupilage under a practising Engineer might be replaced by a corresponding pupilage on the Government works, and under the superintendence and direction of their Engineers. In this case the attainment of certain proficiency, to be attested by a degree to be granted on examination by one of the Indian universities, might, and, I think, ought to be made an absolute condition of further advancement.

J. M. H.

FROM MR. CALLCOTT REILLY.

To the President and Council of
The Institution of Civil Engineers.

GENTLEMEN,

The just regard for the improvement of professional knowledge which has already been exhibited by the Council of the Institution, and the readiness with which they have listened to previous suggestions for increasing the usefulness of the Institution to those who aspire to sound and thorough professional attainments, induce me to venture to submit, with great deference, an outline of a scheme for the further advancement of these important objects.

The purpose of the scheme now submitted, is to make use of the influence and the resources of the Institution in an attempt to provide encouragement and facilities for the pursuit of systematic courses of what may be called "Assisted Self-instruction," in the scientific and theoretical branches of knowledge applicable to the work of the Engineer, by those Members, Associates, and Students of the Institution who may desire it. The main features of this scheme are:

The establishment, and eventual endowment, of seven or eight "Readerships," one in each department of Engineering knowledge, and which might be designated as follows:—

1. A Readership in the theory of fixed structures in ironwork and timber, as iron and timber bridges, roofs, and framework in general;
2. A Readership in the branches of science applicable to the construction of railways and roads;
3. A Readership in those applicable to dock and harbour engineering;
4. A Readership in those applicable to the construction of machinery and prime movers;
5. A Readership in those applicable to municipal engineering, including water supply, the manufacture of gas, and the drainage of towns;
6. A Readership in those applicable to telegraph engineering;
7. A Readership in those applicable to mining and metallurgy;
8. A Readership in pure mathematics.

It is submitted, that the subdivision of the work into numerous departments will facilitate arrangements for the study of each, as also the selection of "Readers" having great special knowledge.

It would probably be impossible, at first, to appoint a separate

Reader in each of the preceding departments, but a beginning might be made with *three or four*, each taking *two or more* departments under his charge. Eventually the number of Readers might be increased, if that should be deemed expedient, as the resources available permitted.

The first duty of a Reader would be to arrange a programme of study, and to select and recommend the text-books most suitable for the private study of the students; and where such text-books do not exist in our language, the resources of the Institution might be reasonably employed in stimulating or assisting their composition and publication, or in authorizing and assisting the translation of those which exist in foreign languages.

The next duty of a Reader, and that the most important, would be the giving of advice and private explanations upon points of difficulty to all students, of whatever class, who having taken up a systematic course of study in the Reader's department should apply to him for such advice and explanation. To guard against the abuse of this privilege, it might be necessary to rule that the right of the student to such assistance, should be confined to difficulties which arise in the study of the text-books themselves, leaving him to grapple alone with such as arise in the application of the knowledge he is seeking to his own professional practice.

The remaining duty of a Reader would be to deliver lectures upon special points of difficulty insufficiently treated in the text-books, or which he may consider are to be taught better by oral explanation, and public illustration in lectures, than by reading. Should the number of earnest students become sufficient to support and justify the expense, then it might be arranged that the Reader should deliver systematic courses of lectures upon the whole subject of his department, and, if thought expedient, the results of such systematic teaching might be tested by periodical voluntary examinations, some honorary distinction being conferred by the Institution upon those candidates who attain a certain minimum standard of proficiency. I further submit that there should be no limitations to the age of those who desire to profit by these facilities for study, nor of the candidates for the voluntary examinations; but that the advantages of the system should be open to all, of whatever class, connected with the Institution.

The establishment of some such organisation as above suggested, would properly be preceded by a systematic inquiry into the state of professional education of Engineers in France and Germany. Therefore I venture to propose that a competent Commissioner be selected by the Council, and sent to those countries, provided with ample means for conducting an investigation into the systems of education there adopted, their cost to the students and to the State, and, as far as possible, their effects upon the profession in those countries. Also that he be instructed to prepare an exhaustive report upon the whole subject, accompanied by a programme of such a system of instruction as, if properly carried into practice, may be expected to yield similar and equal results in this country. Such a report and programme circulated among the members of all classes of the Institution would, it is hoped, create a public opinion in the profession favourable to the establishment of some such system as is now suggested, or possibly something a great deal better.

It will doubtless not be difficult to select from among the ranks of the Institution a competent man as Commissioner. A gentleman must be found who combines high scientific attainments with the habit of systematic inquiry, and who is familiar with the languages of the countries he will have to visit.

The preceding scheme is suggested as one which would produce results *supplementary to* and *independent of* those following upon the establishment by the State, or otherwise, of Colleges or Polytechnic Schools, for the preliminary special education of Engineers and Architects.

The great importance of this subject will be admitted by all, and with the lessons of the Paris Exhibition of this year still fresh in our minds, it will scarcely be necessary to adduce arguments in support of the view, that some systematic effort must be immediately initiated to stimulate and aid the acquirement of that thorough knowledge of the exact sciences and their applications which is the only foundation upon which the Engineer can build a superstructure of genuine professional skill. It is becoming apparent that the possession of that knowledge in a very high degree by most French and German Engineers, and the want of it by many British Engineers, is giving the former an advantage in the competition for professional employment in foreign markets, against which the latter, remaining as they are, can only maintain a struggle, ever becoming more and more hopeless.

I remain, Gentlemen,
Your obedient Servant,
CALLCOTT REILLY,
Assoc. Inst. C.E.

3, Storey's Gate, Great George Street, Westminster,
October 30th, 1867.

EXTRACTS, FROM PUBLISHED DOCUMENTS, BEARING ON THE SUBJECT OF ENGINEERING EDUCATION.

OPENING ADDRESS OF JOHN FOWLER, ESQ., PRES. INST. C.E., 9TH JAN., 1866.

From the many excellent remarks on Engineering Education contained in this address, the following may be quoted as bearing on the subject generally.

With respect to the special preparation of young men, between the ages of fourteen and seventeen or eighteen, several of the largest and best proprietary schools and colleges in this country have special classes and departments for the study of the applied sciences; and thence well-prepared pupils are annually sent out to commence their career with engineers, architects, and surveyors; but still the character of this special preparation, in its theoretical branches, is not considered quite equal to that of France or Germany for the Civil Engineer.

It is true that nearly all continental nations have an advantage over this country in the power which the nature of their government gives them of concentrating, in one recognised official school for the preparation of Civil Engineers, all the best available talent of their country.

This plan does not exist in our country, and on the whole we rejoice that it does not; neither does the inducement of Government employment form the chief stimulus to our exertion, for which we are also thankful; but at the same time no good reason can exist why the opportunities of acquiring theoretical preparation in this country should be inferior to those of the Continent: and I have the confident hope, from the anxiety which is now manifested to increase the ranks of our profession, and the desire to have the best possible preparation for it, that even in the theoretical branches we shall shortly have to acknowledge no inferiority to any other nation. In the practical branches we are admittedly superior.

In drawing attention, however, to a comparison between our own and other countries, let me be guarded against the possibility of being understood to suggest that this theoretical equality ought to be obtained by any sacrifice whatever of our undoubted great practical knowledge; indeed, on the contrary, I think that the attention to the greater opportunities which young Engineers in this country enjoy, by reason of the number and character of our new public works, than is attainable in other countries, should be constantly encouraged to the utmost possible extent, and that our old superiority as practical Engineers should be ever maintained.

OPENING ADDRESS OF C. VIGNOLES, ESQ., PRES. INST. C.E., 11TH JAN., 1870.

This address also may be referred to as giving a lucid description of the status of French Engineers, in corroboration of the facts expressed in the special communications printed in this collection.

REPORT OF THE SOCIETY OF ARTS ON TECHNICAL EDUCATION.

A few years ago the Society of Arts appointed a Sub-committee to consider the subject of technical education. In their Report (which is without date), this body make the following remarks:

The Sub-committee were led to use the term "technical education," as meaning "general instruction in those sciences, the principles of which are applicable to various employments of life," and further to consider only the following employments, so far as the higher grades of education were concerned:

The Civil Engineer.
The Mechanical Engineer.
The Architect.
The Chemical Manufacturer.
The Agriculturist.
The Metallurgist.
The Miner.
The Merchant.
The Officers of the Army and Navy.
" " " Mercantile Marine.

As regards the higher education, which will be first considered, two distinct schemes were discussed. Firstly, technical education might be given in special schools. Secondly, in institutions devoted to the general purposes of education. Special colleges for the education of the members of all the above professions are to be found abroad. The polytechnic schools of Germany and Switzerland were especially urged upon the Committee as worthy of imitation. Sufficient evidence exists that in those institutions good scientific instruction is combined with practical training to an extent which Englishmen can hardly credit, unaccustomed as they are to see practical work learned otherwise than by practice. While, however, your Sub-committee recognise the great merits of these institutions, they do not recommend them for imitation, but, on the contrary, resolved —"That technical instruction, as defined above, should not as a rule be given in separate professional institutions, but in institutions established for general education."

The reasons for this conclusion may briefly be stated as follows:

Where training in polytechnic schools is adopted, the system of pupilage does not obtain; the number of years at the disposal of young men for their professional training does not allow of the combination of the higher school teaching with the teaching by pupilage, and of the two the latter is considered preferable. It would also be almost impossible, even if it were desirable, to substitute the foreign for the English system, and there is certainly no such clear advantage gained abroad as would justify the attempt. As a minor reason, may be mentioned the great difficulty in obtaining duly qualified professors. Very few of the foreign institutions are self-supporting, and in this country, competing against the pupilage system, they would need to be supported by very large Government grants, such as should not be given to secure a doubtful advantage. New special schools of the highest grade would also, in many places, compete with existing universities and colleges, and it would be improper to support by Government aid the special school, giving the narrower course of instruction, rather than the university or college, giving the more general culture and more purely scientific training.

The foreign polytechnic schools include a large number of classes for teaching pure science; these could be as well held, if not better, in universities or institutions giving a general education, and it is this part of the training which the Sub-committee are chiefly desirous of recommending for imitation, not the practical portion, which is better given by the pupilage system. Again, our universities and colleges can readily adopt some courses on the applications of science, and thus provide such special teaching as may with advantage be given in class-rooms at much less expense than would be entailed by the institution of special schools. On these grounds the Committee decided against the institution of special professional schools as a rule.

None of the objections to these schools apply to special courses of study intended to fit students for a subsequent pupilage. The Committee, therefore, for the guidance of parents, students, and colleges, obtained reports on special courses adapted for each business from those members of the Committee who were specially conversant with each subject. The reports of these gentlemen are appended, and contain many valuable practical suggestions, but they rest solely on the authority of the gentlemen whose names are attached to them, and have not been adopted by the Committee. The uniformity as to certain subjects suggested is remarkable. Ten reports were received: of these all include mathematics, nine physics, nine chemistry, nine mechanical drawing. When these, which may truly be termed the mother sciences, have been stated, the other subjects appear in far smaller proportions. Three schemes include mineralogy, two geology, five applied mechanics under various titles.

With the exception of the reports presented by one gentleman, and the report on a mercantile education, all leave the special applications of science to the particular profession or business for the last year in the course; and although in this last year there was a clear concurrence in the recommendation of some special studies, there is a still more marked unanimity in recommending the study of pure science as the best groundwork for all technical education. The special applications of each science may be learnt in practice if a sound education in scientific principles has been received in early life. Without this sound elementary training, the teaching of applied science at the best can only mean dogmatic instruction in rules which are not understood, and is liable to degenerate into mere quackery or child's play.

When the pupilage system takes the place of the foreign polytechnic school, and when it is understood that the best preparation for pupilage is instruction in pure science—it becomes clear that the colleges preparing students to become pupils must be institutions left by students at about the age of eighteen, and that these institutions will correspond far more nearly to the gymnasia and *lycées* of the Continent than to the universities or polytechnic schools. What is required is that students should enter on their pupilage as well instructed as foreign students enter the special schools of the Continent. This can be effected by existing colleges, if these institutions are willing to organize special courses of study, and found new chairs for professors of certain special applications of science. What those chairs should be may be gathered from the courses recommended in the appendix.

The existing colleges are, however, too few and too widely scattered to educate more than a small proportion of those who ought to receive a scientific education preparatory to technical pursuits. New colleges are therefore required; colleges of a type analogous to Owens College, and schools which would either prepare students for these colleges, or be analogous in their highest forms to those institutions. The class of schools required does not at present exist in England.

When existing colleges have organised the proposed courses of study, and when the new schools, leading to those colleges, or giving analogous preparation for the scientific professions, have been established, it will be necessary that the proficiency of the students and the efficiency of the teaching should be tested by methodical examinations; and, in order that students should be induced, by a tangible reward, to present themselves well prepared for these examinations, it is desirable that diplomas or certificates should be granted for approved excellence. There would be serious objections to the granting of diplomas to civil engineers, architects, &c., if these diplomas were supposed to certify that, after a merely scholastic education, the students were ready to practise their professions, but there are no objections to certificates which simply attest that the student has attained such proficiency in his theoretical studies that he is fitted to enter on a practical pupilage with advantage to himself and his employer. The certificates will also be a valuable recommendation in early professional life, if they are granted with discretion. They might either be granted by some one public examining body in each profession, or by the various colleges where the higher studies are carried on. The Committee prefer the latter plan, as less likely to lead to one monotonous system of teaching; but they feel that certain guarantees must be taken, lest a sort of Dutch auction should occur, in which the inferior schools and colleges would bid for pupils by granting certificates for smaller and smaller acquirements. Such conduct would no doubt bring its own remedy in time, but, to avoid the occurrence of the evil, the Committee consider that the examinations at each school and college should be conducted with the assistance of two independent examiners, one appointed by the Government and one by the leading professional institute belonging to the profession with which the examination was connected. These two examiners should also report on the proficiency of the students at the various institutions, and would thus perform the office of inspectors, without subjecting the professors of the higher colleges to any degrading supervision.

After this good scientific instruction, tested by examination, comes the pupilage in all cases, and after the pupilage it is desirable that voluntary public examinations should be held, with the view of testing whether the young men have really profited by their pupilage. This examination, which should be partly practical and partly theoretical, might be conducted by similar boards of examiners to those specified above; and diplomas, which would then express real proficiency in the several professions, should only be granted to young men of undoubted merit. Severe examinations of this type are conducted at Carlsruhe and other large polytechnic schools on the Continent.

The above recommendations are an expansion and explanation of the resolutions:—"That it is desirable that the higher scientific instruction should be tested by public examination, and that the proficiency of persons who pass these examinations should be certified by diploma;" and "That the preparation for the businesses considered by the Committee is not sufficient until due scientific instruction has been followed by practical pupilage in efficient works."

When, however, a methodical course of study has been rendered possible for each profession, and examinations have been instituted for testing the proficiency of students, it will at first be difficult to fill the classes of the new schools, and to induce young men in any numbers to present themselves for examination. It is incumbent on all those who really believe in scientific teaching to prove their faith by giving a practical value to the certificates obtained by students. This can be done only by the employers of labour, who must at first act on faith only. Hitherto no class of young Englishmen, trained in the manner proposed, has existed. In order to induce the rising students to follow this methodical training, they must see that the few who take that course do find employment more readily than those who do not. The employers of scientific labour can give an enormous impulse to scientific training by showing a real preference for young men who have passed through the courses of study recommended. Thus engineers and architects ought to receive pupils more readily who are well trained; they might reduce their premiums for such pupils; they should grant free pupilships as rewards for very successful public examinations; they might give privileges in their professional institutes to the holders of diplomas. The Committee "recommend employers of labour and others in the habit of taking pupils, apprentices, and clerks, to give the preference as far as possible to those adducing evidence of the possession of adequate instruction in the sciences applicable respectively to their professions or occupations."

Professor Fleeming Jenkin, in an Appendix to the Report, proposes the following course for preliminary education of Engineering students:

CIVIL ENGINEER.

A TWO YEARS' COURSE.

[No student should be allowed to enter on a course of special study until he has passed an examination, proving that he has received a sound preliminary education not having special reference to his profession.]

Pure Mathematics . . .	Algebra. Plane and Solid Geometry. Trigonometry.
Natural Philosophy . .	A general course on the properties of matter, and some one branch, such as Heat, Optics, Electricity, &c.

Chemistry (inorganic), with laboratory practice.
Geology, including instruction in the field.
Mathematics applied to Mechanics.
The application of Science to Civil Engineering.
The application of Science to Mechanical Engineering, Surveying, and Levelling.

Drawing	Geometrical Projection. Mechanical Drawing. Plans and Surveys.

After passing an examination in these subjects the student should enter a civil engineer's office as pupil, and examinations should be instituted by which his knowledge, at the end of his pupilage, could be tested. These examinations should be on special and limited subjects, but in these subjects they should be of a severe and searching character. They should comprise two groups of subjects—theoretical and practical—out of which the candidate should select one in each group.

Group 1.—Practical Engineering.

(*a.*) The preparation of designs, specifications, and contents for some civil engineering work.

(*b.*) The design of machinery, &c.; complete drawings, specifications, and estimates.

Group 2.—Applied Science.

(*a.*) Pure Mathematics (higher calculus).
(*b.*) Mathematics applied to Mechanics.
(*c.*) Chemistry, Geology, or some other branch of experimental physics.
(*d.*) Telegraphy.

3rd. Students should not be encouraged to select more than one subject in each group.

All these examinations should at present be voluntary, but it would be most desirable that the leading engineers should refuse to receive as pupils young men who had not passed an examination showing their fitness to enter the office with advantage to themselves.

FLEEMING JENKIN.

Mr. Scott Russell proposes the following course for

THE MECHANICAL ENGINEER AND MACHINIST.

A THREE YEARS' COURSE.

First Year.

Pure science	Mathematics. Physics. Chemistry.
Applications of science . .	Descriptive Geometry. Elements of Mechanism. Strength of Materials of Construction.

Practical work in laboratories and drawing office and museums to accompany each study.

Second Year.

Pure science	Mathematics. Physics. Natural History.
Applications of science . .	Constructive Geometry. Prime Movers and Steam Engines. Nature of Raw Materials. History of Inventions. Elements of Mechanism.

Practical work in laboratories and drawing office and museums to accompany each study.

Third Year.

Pure science	Mathematics. Ultimate Mathematical Physics. Political Economy.
Applications of science . .	Statics of Machinery. Hydraulic Machinery. Prime Movers. Electro-magnetic Mechanism. Engine Tools. Metallurgy. Design of Factories.

Practical work to be carried on in laboratories, drawing office, and museums, and collections of machinery during the Session.

Practical work in factories and workshops should, if possible, alternate with study in periods of six months.

At the end of apprenticeship a course of travel, with work and study, should be recommended.

J. SCOTT RUSSELL.

PROFESSOR FLEEMING JENKYN ON ENGINEERING EDUCATION.

The following remarks on comparative Engineering Education at home and abroad are taken from—

A Lecture on the Education of Civil and Mechanical Engineers in Great Britain and Abroad; being a public Inaugural Address delivered in the University of Edinburgh, on Tuesday, 3rd November, 1868. *By Fleeming Jenkyn, M. Inst. C.E., F.R.S. Edinburgh,* 1868.

The position of an engineer abroad, in general, differs much from that of his English colleague or competitor, and in France the difference is greater than in any other country.

The distinction existing here between civil and mechanical engineers is far more strongly marked in France. And the business of the civil engineer, who is occupied with roads, railways, canals, rivers, harbours, mines, is almost exclusively in the hands of the members of the body called the Engineers of the *Ponts et Chaussées*, forming an important branch of the public service. These Government officials correspond to our civil engineers; they are allowed, and even encouraged, to enter the service of private companies and large establishments, but remain all their lives members of their corps; and supported as they are by Government patronage, by tradition, by their *esprit de corps* and mutual assistance, and lastly, by their acknowledged distinction and honourable conduct, they enjoy so great an advantage over any independent man who may try to compete with them, that the civil engineer proper only exists as an exception in France. Once a member of the corps, a man is honourably provided for in life: he enjoys rank, certain promotion, a fair income, and, if he have original talent, a certainty of opportunities of largely increasing that income. Nothing, you will see, can possibly be more different from the career of an English engineer, to whom the Government is usually nothing, unless it be looked upon as a foe from whom recognition and remuneration is to be won by sheer hard fighting.

Being public servants, French engineers are educated by Government, and in great part at Government expense; the career, being so advantageous, is desired by the *élite* of the French youth, and hence in the competition which determines the admission of students to the Polytechnic School, as the school of engineers is termed, we see 900 picked pupils of eighteen and nineteen, each straining every nerve to win one of 150 appointments annually made. I believe that there exists no competition in Europe comparable with this. The great severity of the examination is so well known, the fact that five out of six must fail is so obvious, that none but young men who have already gained distinction in the great public schools dream of competing. But the select 150 are a long way yet from the practical part of their profession. For two years longer they are employed in purely theoretical studies, that is to say, the higher mathematics, theoretical mechanics, mathematical physics, curious problems in descriptive geometry, with a little drawing and language as recreations. During these two years each of the 150 is engaged in a daily struggle for about five-and-twenty highly-coveted posts. The three who are at the head of the class-list at the end of the two years gain the proud title of Engineers of Mines, the rest are humbler members of the *Ponts et Chaussées*, while the 125 who fail have to content themselves with looking after the State factories for powder, tobacco, or saltpetre, or, worse still in their estimation, they sink into mere royal engineers or artillerymen. They may even fall as low as the navy or marine-artillery, for, strange as it may seem with our misconceptions of the French character, the civil appointments rank infinitely higher in the estimation of the competitors than the military posts.

Let us accompany them a little further on their career. They have not yet got to practical work. For three years they attend another school, the school of the *Ponts et Chaussées*, or the school for engineers distinctively. Here they are taught in classes how to apply their theoretical knowledge to practical problems, and for six months in each year they are sent into the country to see some practical work; there are no more competitions, and the life is now an easy one; at the age of about four or five and twenty they leave college and are sent into the provinces to begin real work, which for them is chiefly a matter of routine, concerning the administration of the law as to the maintenance of all public works under Government control or inspection,—*i.e.*, in France, roads, canals, rivers, harbours, railways, and telegraphs. Too often the young man who has received a mathematical training equal to any that Cambridge can give, sinks into apathy under this occupation, and plods his life through in a lazy comfort, without ambition, but with no fear as to the future, without failure, but without success.

In the education given to mechanical engineers in France, we find much that is worthy of our admiration. Their mechanicians form no guild, protected against competition; they have to work and strive, subject to the same hard laws which determine commercial success abroad as at home, and they are rivals whom we must respect, if we do not fear them. Their marked success of late years has chiefly led to the demand for a better technical education in England, it being well known that much of their success was due to the excellent education which they received, chiefly in the École Centrale of Paris—where the instruction given is very similar to that offered by the great polytechnic schools of Germany and Switzerland. These great colleges at Zürich, Carlsruhe, Stuttgardt, and several other German towns, offer, with the École Centrale of Paris, an education to engineers which is altogether admirable, so far as that education can be given in colleges. They are all protected by an entrance examination, only a few degrees less severe than that required to win an appointment to the French polytechnic school; they have no posts or appointments to offer as prizes, and yet crowds of students annually strive hard to gain the mere privilege of admission.

Now, abroad, this path to the work of an engineer lies through these great colleges. The English system of apprenticeship does not exist, consequently the one letter of recommendation which proves that a young man is worth a salary in an engineer's office, or in a mechanical workshop, is a diploma from a polytechnic school. Therefore the schools are full. In England, the path to employment as an engineer lies through the office or workshop of a civil or mechanical engineer, and therefore we find that young Englishmen and their parents crowd the doors of the offices and workshops, offering premiums of £300 or £500 for the mere permission to pass three years unheeded inside the magic gates, which must be passed to gain an entrance into the profession. True, abroad there is no law which requires a diploma from a man before he can practise. True, in Great Britain men may and do rise from the ranks, and become the most eminent of all our engineers, but it is not the less true that a young foreigner of education finds the only recognised entrance to his profession through the colleges, and that a young man here must look to pupilage or apprenticeship as the only recognised beginning to his career as an engineer.

The two systems cannot well be combined. The foreign plan requires a young man to study in a college till the age of about twenty-three, when it is too late for him to think of entering an office or workshop for three more years, paying a heavy premium and receiving no salary.

Before considering which is the best system, it will be well to give you a somewhat fuller account of what is done in these great technical schools. At Zürich and at Carlsruhe a staff of from forty to fifty competent professors gives a technical education to the students. Not only do they teach mathematics, mechanics, physics, geology, chemistry, but they teach how the knowledge of all these elements is to be applied to practical problems in every department of engineering. The pupil begins by designing screws, bolts, rivets, or walls, and culverts, and ends by designing under the master's eye, the most complex machines and the most elaborate bridges and harbours; he is shown the practice of all nations; he is forced to calculate his work so as to meet the requirements of real problems, and so thoroughly is this done, that students do leave these colleges well able to earn a good salary in the drawing-office of the civil and mechanical engineer. I could not have believed this to have been possible had I not seen it; and my personal inspection of the colleges taught me to marvel at the combination of theoretical with practical knowledge evinced by the German Professors. At the École Centrale I found that the system was similar; in addition to the usual courses of lectures, projects were each month submitted to each class; that is to say, they received a short specification of a certain work to be designed. The designs, specifications, and estimates were to be ready in one month's time. Meanwhile each pupil was free to consult books, friends, even the Professor himself, but he was bound to produce an original design, making the drawings in the class-room. When each design had been sent in, the Professor cross-examined every pupil as to his motives for choosing the dimensions, materials, and forms adopted, and finally, he corrected and criticised the design. Couple with this, admirable lessons in the higher mathematics, pure and applied, and you will not wonder that the École Centrale turns out men who are thorough masters of the theory and practice of design applied to engineering works.

This is the foreign system. What is ours?

Young men, at the age of about eighteen, enter the office of a civil engineer. Usually few questions are asked as to previous training. Etiquette requires the engineer to show a certain reluctance to receive the pupil, and, in fact, the ordinary pupil is a sort of nuisance in an office, only tolerated in consideration of the fee which accompanies him. From personal experience I can declare, that most pupils are so ignorant of algebra, that they are not only incapable of working out a result for themselves, but actually cannot apply the simple formulæ which are given in engineers' pocket-books. The calculation of the solid contents of a wall is often beyond their powers. Their arithmetic is very shaky, and a knowledge of physics, chemistry, geology, or the higher mathematics is wonderfully rare. The men have too often chosen the profession from an idea that it is pleasant, and because, forsooth, it is guarded by no preliminary examination. Not even a pass-examination is required, and the ignorance of some pupils, especially in mechanical workshops, must be experienced before it can be believed. They really seem to think that a little turn for making toy-models shows a bent for mechanical engineering such as will justify them in expecting success.

These young men during three years have the run of the office or workshop, and if they are intelligent, towards the end of their pupilage often have opportunities of seeing actual work in the field, or of designing some parts of actual machinery, and of assisting in the erection of more or less important works. No one teaches them anything; but they have the opportunity of seeing how some actual work is done; they see just how much mathematics is absolutely required, and they pick it up. They see how workmen are managed, and learn their habits; they are brought into contact with the exact class of work which they will have to perform, and they know that unless soon they are competent to do this work, they will not have a chance of employment. The one point for them is, to convince their masters that they are useful, and hence, notwithstanding their ignorance at starting, the neglect in which they are left during their pupilage, the absence of opportunities for improving their theoretical acquirements, many of them do become useful men.

The contrast between the two systems is complete: abroad, men have almost perfect theoretical instruction, coupled with a wonderfully good imitation of the real work, so far as design is concerned; they are not brought into contact with the execution of those designs until they begin to gain their bread. In England, the theoretical instruction is wofully deficient, but the abler men are allowed to design real work, and they watch the execution of that work in many stages. Abroad, competitive examinations keep out incompetent men; in Britain they are weeded out by the result of the struggle for existence. Abroad, great numbers pass through the same school, making the same designs, in great variety, under the same Professors. Here, each man sees different work, but of a limited kind.

Before deciding which system is the best, or what modification of the two is desirable, we ought to form some idea of what the work of an engineer is.

As a civil engineer, the young man is called upon to design small works, such as bridges or culverts, according to some well-established type—little originality is wanted, and just so much theory as will allow him to make safely the slight modifications required to meet each case; he superintends the execution of work by contractors, and must know good from bad work when he sees it; he must have such a knowledge of mensuration as will allow him to certify exactly the quantities of work done by the contractor. He must be able to survey on occasion, to level with great rapidity and accuracy, and to set out work in the field. He must have such a knowledge of the world as will enable him to deal pleasantly and firmly with workmen, contractors, and proprietors on whose land the works are being constructed. Above all, he must be a thoroughly honourable man, wholly above suspicion of taking bribes from contractors, of cooking his work, of concealing any blunders he may make, or of absenting himself from his duties.

Colleges cannot teach young men all these things, and my own experience has confirmed the conclusion, that a gentlemanly man of fair education and intelligence, after working as a pupil for three years in a civil engineer's office, is, for subordinate positions as a civil engineer, a more useful man than the pupil of a foreign school.

For a mechanical engineer the case is different. The younger men in factories have to design machinery frequently of one type, but nevertheless varying so much from year to year, that a sound knowledge of mathematics, mechanics, and physics, is of the greatest importance to them; consequently, as draughtsmen or designers we find foreigners employed all over the country. And *à priori* I would rather engage a foreigner to carry out my ideas in designing a new machine than a young Englishman of equal standing, especially as most of the foreigners complete their education by working in a shop for a short period.

As they rise in their professions, engineers are called upon to display higher and somewhat different qualities. The civil engineer may be called upon really to design great works and novel works; and here Englishmen feel sadly the want of a sound theoretical training. But even in the higher walks of the profession, design and invention are required much less than is usually supposed. The leading engineer must be a man of good business habits, able to advise the directors of great companies prudently as to the probable cost and revenue of proposed works. He must have the head of a lawyer in drawing up specifications and revising contracts. He must be able to choose his subordinates wisely, and keep them in good discipline. In a word, he must be a man of great Common Sense.

As a mechanical engineer, or as a contracting engineer, a knowledge of trade, a keen eye for economy in details, and a thorough practical knowledge of the properties of the materials he employs, must be added to the above list of talents; and when we reflect how very few of the above qualities can be taught at colleges, we understand how it is possible that our engineers should justly take a high rank in the estimation of the world.

You will long since have anticipated my conclusion,—that there is no reason for abandoning our system of apprenticeship or pupilage, to substitute for it the foreign plan of large special colleges, even if we could hope to create colleges of equal merit with those formed abroad.

But this conclusion, instead of leading us to sit down wrapped comfortably in a veil of blinding self-conceit, ought rather to urge us to work with the greater vigour at removing the acknowledged defects of the British plan. We have not to construct the whole edifice anew, we have only to put on the cornice-stone.

Our defect is the want of a good knowledge of the theories affecting our practice.

It must be admitted that of this knowledge we possess far less than is necessary. By dint of sheer hard thinking and repeated trials, we somehow do solve most problems; and the plan of Brindley, who used to go to bed when he was posed, and think steadily for a day or two, is by no means a bad one. But our success costs a vast expenditure of money and of brain, which could be turned to better purpose if we knew how to calculate the results to be expected from a given combination with some certainty beforehand. And not only does our ignorance cause much wealth to be wasted by the community in useless trials, but it prevents the trial of many new schemes, because the engineers or managers to whom they are submitted feel that they have no means of judging beforehand of the probability of success, so they, wisely in their generation, think they had better stick to the old plans, and in nine cases out of ten they are right; but the rejection of the tenth case is a dead loss to themselves and to the country.

How much theory, as it is called, does the engineer want to enable him to judge soundly and design correctly? Certainly much less than is given abroad.

I have no doubt that the engineering student of average ability might acquire a sufficient knowledge of theory before his apprenticeship begins, or during its course. The very entrance-examinations required by the foreign colleges are a proof of this. These examinations are passed by young men of seventeen, eighteen, nineteen, and if our pupils could enter on their apprenticeship as well educated as the foreigners when they enter their special schools, I am convinced that the British would in every respect be far superior to the foreign system. Our engineers would then start in life with a good knowledge of algebra, trigonometry, mensuration, drawing, the elements of physics and chemistry. The few who had the turn for higher mathematics could pursue their studies in after life, but all would be saved the weary time now lost in offices by zealous men trying vainly to understand the simplest formulæ, and gradually picking up through practice the power of mensuration, and of representing ordinary geometrical forms by mechanical drawing. In addition, it would clearly be of great advantage that they should, before being brought in contact with practical work, have had their attention drawn to the manner in which all these branches of knowledge are applied to the solution of practical problems. The manner in which estimates are made, specifications drawn, and contracts framed, can be indicated by special examples. Above all, it is possible to inculcate the true principles of economy upon the mind of the student, who should never forget that the object of the engineer is not to display his ingenuity by the production of ingenious devices, but to use his judgment and invention so as continually to endeavour to increase production at a diminished cost.

Diplomas of engineering are no novelties abroad; they are granted by all the large and successful colleges; they are the object of a most legitimate ambition, and testify to facts which can be ascertained with certainty. No diploma could be granted by this University certifying that a man who had only studied here was fit to practise the profession of an engineer; a diploma following on college studies ought only to declare that the student is fit to enter the office or the workshop with advantage to himself and his employer; but there is no reason why, after some years of practical work, the engineer should not return to the university, and by passing a voluntary examination, both in matters of theory and of practice—such an examination as is actually conducted in Germany,—obtain a degree or diploma which should really be a guarantee that in certain branches he was a competent engineer. The arguments in favour of an Engineering degree may be thus shortly stated:—the profession is well defined; the studies required by its followers are of a scientific kind, well suited for collegiate examination; a motive for systematic study is urgently required and, lastly, a means of distinguishing themselves is earnestly desired by young engineers on the termination of their pupilage. Now, personal distinction is wholly denied to the young engineer; he works for others, and the merit of his work falls to the credit of his employer, who is responsible for it to the outer world; some means of distinction, such as is afforded by a degree, would greatly tend to induce men, after leaving the university, to continue their studies. I really know of no objection to the creation of a degree or the granting of a diploma, except that it is a novelty in Great Britain, and might be misused by inferior institutions.

Mr. Jenkin also, in a letter to the Secretary of the Institution, adds the following observations:

It is out of the question that any college training should replace the system of apprenticeship, but it is most desirable that pupils should enter offices better prepared than at present, and that they should continue their theoretical studies during their apprenticeship.

We do not require special institutions, or any large number of technical chairs, but rather—

1. Great improvement in secondary schools, especially in teaching arithmetic, geometry (abolish Euclid as pestiferous), elements of natural philosophy.

2. The establishment in some large towns, such as Liverpool and Birmingham, of colleges on the Scotch model, or on that of Owens College—fairly well endowed—giving chiefly general scientific training, with a few special technical chairs.

3. The practical recognition of the value of scientific training by Engineers who take pupils.

a. By giving free pupilships as valuable scholarships.

b. By admitting as pupils only those students who have passed certain recognised examinations.

c. By co-operating with colleges as examiners.

d. By inserting in agreements with their pupils that during the winter they shall attend certain classes (done here).

e. By giving some privileges in connection with the Engineering societies to graduates.

MR. SCOTT RUSSELL ON TECHNICAL EDUCATION.

The following extracts are taken from—

Systematic Technical Education for the English People. By John Scott Russell, Esq., M.A., F.R.S. L. & E., M. Inst. C.E., &c., London, 1869.

In this able and instructive work, the Author makes an elaborate comparison between British and foreign technical education, much to the disavantage of the former, points out with much force the evils to be apprehended from the competition of foreign nations in technical matters under their superior education, and proposes a remedy by the organisation of new technical, science, and trade schools throughout England.

The following extracts will illustrate most of Mr. Scott Russell's views as bear most particularly on the education of Engineers:

> I will now come to the practical matters which show directly the results of a technical education in the production of one of its chief objects—the creation of wealth. It is notorious that those foreign railways which have been made by themselves in the educated countries of Germany and Switzerland, have been made far cheaper than those constructed by us in England; it is known that they have been made by pupils of the industrial schools and technical colleges of these countries, and I know many of their distinguished men who take pride in saying that they owe their positions entirely to their technical schools. I find everywhere throughout their work marks of that method, order, symmetry, and absence of waste which arise from plans well thought out, the judicious application of principles, conscientious parsimony, and a high feeling of professional responsibility. In the accurate cutting of their slopes and embankments, in the careful design and thoughtful execution of their beautiful but economical stonemasonry, in the self-denying economy of their large span bridges, the experienced traveller can read as he travels the work of a superiorly educated class of men; and when we come down to details, to the construction of permanent way, arrangements of signals, points, and sidings, and the endless details of stations, we everywhere feel that we are in the hands of men who have spared no pains, and who have applied high professional skill to minute details. It is well known that many years before we would follow their example, the engineers of the German railways had introduced a system of constructing and of uniting to each other the iron rails of the permanent way, which made them cheaper, more durable and safe than those employed in England. Happily for our national reputation it was an Irishman who invented it, though its advantages had first to be appreciated in Germany before we would follow the example.
>
> It is remarked by every traveller that the works of their railway stations are, when compared with ours, much more beautiful, convenient, and fit, both within and without; the construction of their trains, the proportions of their carriages, the fitness, convenience, and comfort of their internal arrangements, all tell to the disadvantage of ours; and the one thing in which our railways excel theirs is in high speed. Theirs, on the other hand, are economical in capital and high in revenue.

In 1855 we saw that the French and the Germans had already advanced far into our own provinces of iron, steel, and metal manufacture. We found that they had already established schools in every metropolis, large town, or centre of industry, for educating professional men and masters, for training foremen and skilled workmen, and for educating apprentices. What we saw in 1855 was instructive to the clear-sighted and the thoughtful; but it was not humiliating to the mass of the English visitors, and it did not alarm the English manufacturers. Therefore, unhappily, they did not take warning in time. They merely committed the common blunder of despising their rivals. When they saw the enormous progress of the French in steam machinery, and its metal products occupying a huge annexe, they merely said: "Look! they have been imitating us; but never mind, these are mere *tours de force* got up under the patronage of the Emperor to make a show at his Exhibition. They serve to gratify the vanity of the French nation, but they can never compete with us in quality, quantity, or price."

This self-satisfaction was a huge blunder. The progress of the French and German nations has shown there was an ominous reality.

France had been diligently following up her determination to equal us in our great staples of machinery and iron manufacture, and the stately steam-engines she then produced as examples of her ordinary work in the steam-ships of her navy and mercantile marine, sufficed to show us that her progress was true, and that we had been mistaken in calling her triumphs of 1855 *tours de force.* All around us in that Exhibition were proofs that every nation had begun to rival us in some one of our great specialities.

It was the Exhibition of 1867 in Paris which gave the nations, and especially England, a final lesson. By that Exhibition we were rudely awakened and thoroughly alarmed. We then learnt, not that we were equalled, but that we were beaten—not on some points, but by some nation or other on nearly all those points on which we had prided ourselves.

I shall shortly sum up the practical conclusions which I myself and the most eminent of my colleagues arrived at. We were sent by the British Government to serve as jurymen in adjudging the awards of the Exhibition, and to report to the Government the practical facts of national importance which we might there observe. In the great manufactures of iron men-of-war, with their huge steam-engines, ponderous wrought-iron armour, we found ourselves equalled if not beaten. The large marine engine of Dupuy de Lôme neither excelled the English marine engine in exquisite truth of workmanship nor in high finish, for I have elsewhere said that the English workman's conscientious pride in his work is not to be excelled by that of the workmen of any other country. But the design of the French engine showed so much forethought, practical wisdom, and provision for economy, as left no doubt that it would consume less fuel, do more work, endure longer, and run less chance of accident than our own engines; all of these being qualities heretofore constituting our own superiority.

Next in iron armour. Their ships carried iron armour as thick and as strong as our own, and they were armed with guns and supplied with ammunition which could just penetrate that armour, but which that armour was just able to prevent from piercing. And their ships presented arrangements for securing all the advantages of simultaneous firing in every direction which we had claimed for ours, with this additional advantage, that the French had attained that which we had at enormous expense tried but failed in obtaining—efficient breech-loading guns, which *enable them effectually* to deliver 17 shots to our 10.

Thus our naval supremacy was shown to be ended, so far as the manufacture of *matériel* and mechanism is concerned.

Coming to land-machinery and structures, we found in the French department of the great building a multitude of steam-engines of French manufacture, and even from distant provinces, distinguished by our own perfection of mechanical execution and high finish, but distinguished also beyond any of our own for the elegance and perfection of their mechanism and arrangements for economy. With the French, fuel is dear; they find it worth while to fetch it from England and pay the freight, but they have set their minds to compensate this inequality by their superiority of design and contrivance. So they not merely invented boilers well calculated to endure, keep clean, and extract the largest quantity of heat out of the fuel and to make with it high and strong steam, but they also contrived the engines in such a manner as to turn that steam to better account than in our engines, so as to get more power out of a given quantity of fuel, in a higher proportion even than the greater cost of our own fuel exported into France. A clear triumph of forethought and ingenuity over wasteful, unthinking wealth.

There was but one steam-engine which rivalled them, and that was more the contrivance of the American than of the Englishman whose name it bore.

But perhaps the most remarkable group of all the exhibitions in Paris, was the group of large manufactures in iron which showed the products of the furnaces, forges, and iron-mills of France, Germany, and Belgium. Everywhere in rails, railway wheels, railway tyres and axles; in large wrought-iron beams for housebuilding, in iron plates and bars, and frames for iron ships—in these, which were all our own, we found ourselves rivalled, excelled, in size and quality, and competed with in price. On land, therefore, as well as at sea, our mastery of the iron trade seemed to have disappeared.

In smelting, mining, locomotive building, and the great branches of commercial machinery, a single great establishment in France, called Creusot, appeared like a chivalric knight to issue a challenge against all England.

Creusot possesses the natural advantages of England, inasmuch as under its own soil it has the iron, the coal, and other minerals, in the same abundance as ourselves. But Creusot, under the wise direction of President Schneider, was endowed with an advantage which we have neglected—the possession of a systematic organization of technical schools. Creusot has a generation of workmen schooled and trained on the spot. The schools are a model which we shall long emulate in vain. It will take us twelve years to overtake Mr. Schneider. He imports his locomotives even into England; and all round the coasts of France, and round her inland borders, Schneider serves with locomotive engines, iron plates, and forgings, customers who used to come to us for these commodities. It is not in price merely that he competes with us. It happened to me to be professionally occupied in a foreign country where the iron for a large engineering undertaking was about to be contracted for. Competitive tenders were obtained from some of the best works in England, and from Creusot. The prices were so near as to have little influence on the result, but they were slightly in favour of the English manufacturer. The contract was given to Creusot, and when I inquired officially the reason which had sent the contract to France, I was informed that they could more perfectly rely on the uniform excellence of the quality of the iron from Creusot than from England—a result to an English engineer sufficiently humiliating. I asked the value of this character in the opinion of the buyers, and was answered that they considered it equivalent to more than five per cent. in favour of France.

Another fact of the same sort in the same place expressed the same conviction. The large iron forgings which were imported for the same work, came from France, not England. The answer received this time was that the large forgings were cheaper in England than in France, but that in France the forgings were so much better formed to the finished shape as to be worth more than the difference in price.

I have dwelt on these instances mainly because they are in departments in which I can venture to express a professional judgment. In the Prussian department were triumphs of technical skill, palpable to all observers. Steel cannon more powerful than any of our own, carrying larger shot with heavier powder charge. Large ingots of steel, of magnitude and quality unequalled by any nation. Tyres of locomotive wheels, which, imported into England, supersede our own highest qualities of iron; and complicated members of machines forged by Krupp out of a single piece of steel so as to be equivalent to eight or nine of the old pieces, formerly fastened imperfectly into one. These were some of the triumphs hastily exhibited by Prussia, even at the end of her costly war.

The Author cites the Royal College of Naval Architecture at Kensington as almost our only successful attempt at systematic technical education, which, he says, as a rule, does not exist in this country.

The Royal College of Naval Architecture at Kensington is one of the few establishments created by the British Government for the technical education of its professional men.

The Author was one of those members of the Institution of Naval Architects who urged on the Government of the day the establishment of that technical college. Aided by Sir J. Pakington, they succeeded in obtaining the necessary endowment. Her Majesty, who has always been a true friend to the cause of superior education, authorised the founding of a royal college. Mr. Cole, at Kensington, organised the appropriation of buildings and an establishment to that purpose; the Constructor of the Navy's department aided in the organisation of the school; and under Mr. Merrifield as Principal, and Dr. Woolley as Admiralty Inspector, the Royal College of Naval Architecture is now a type of that class of institutions which no English profession ought to continue deprived of, and where young Englishmen may obtain a training which they need not be ashamed to compare with that of similar institutions abroad.

Speaking of the Zurich educational establishment, he says:

Such is our model university; and I ought not to leave it without testifying to its perfect success. My first acquaintance with this university arose out of the incident of a young relation of my own happening to desire to obtain an education in a branch of civil engineering, and finding it impossible to obtain that education in England. Fortunately for him, an Englishman of science, well acquainted with foreign education, recommended to him the technical university of Zurich. He went there: he passed through its courses; returned to England; entered himself in the usual manner as a learner in the works of an eminent Engineer. Here the advantages of Zurich soon showed themselves unmistakeably; his superiority was so evident, that he soon rose over the heads of much older men, and long before his apprenticeship expired, he had already been entrusted with heavy responsibilities and important duties, which could not be entrusted to men much older and more experienced, but less skilfully trained, and less highly educated.

The Author's own views about Engineering education are stated as follows:

What Technical Education should we give to the Mechanical Engineer or Machinist?—From the days of James Watt and Arkwright until now, comprehending the whole of the present century, the mechanical engineer or machinist has formed one of the most important classes of this country, and has conferred on it immeasurable benefit. It was the mechanical engineer and the manufacturer who, together, during the early part of the present century, while the whole of Europe was overrun by the curse of war, created wealth in this country so rapidly, as to enable her to struggle through a burden of expenditure to which there has been no parallel, and to come out of it prosperous and wealthy.

There are no occupations or trades concerning which there could be so little difference of opinion as to the practical importance of special technical education, as this class of mechanical engineer and machinist. Philosophers have defined man as the tool-using animal; but if the man of this century were defined, the "engine-maker" and "machine-user" would be his leading characteristic: it is the triumph of human nature in our time, that it has achieved the understanding of the forces of nature so completely, that whatever material service we wish to perform, we can always discover some elementary force in nature, willing to lend us its aid to conquer our difficulty, provided we will study its nature sufficiently to direct it into the way in which it can best serve our end. The steam-hammer of Nasmyth, and the steel ingots of Krupp, are symbols of the powerful yet plastic forces man wields, in his gigantic shape-compelling processes of manufacture. We may sum up the duties of a man of this craft by saying, that there is scarcely a process now performed by animal or man, which our engineers or machinists of the next generation may not be called upon to perform better and quicker by machines of their own creation.

Of the engineer and machinist it is therefore very easy to indicate the course of instruction; unluckily, much easier to indicate than to accomplish. He must master all the known powers of material nature: heat and cold; weight and impulse; matter in all conditions—liquid, solid, and gaseous; standing or running, condensed or rare, adamantine or plastic—all must be seen through and comprehended, by the master of modern mechanics. The same laws which govern the machinery of the heavens, he has to apply to the machinery of the earth; and the same exquisite mechanism which the Creator has used in the structure of his animals, the modern mechanician has to apply in the construction of his microcosms. The modern mechanician, who would be equal to his work, must be prepared to shape a tool and frame an engine for the execution of tasks which were never even dreamt of by the older mechanicians.

TECHNIC EDUCATION OF THE MECHANICAL ENGINEER AND MACHINIST.

Mechanical Knowledge.	*Technic Education.*
Shapes and sizes of things	Geometry.
Quantities	Algebra.
Numbers	Arithmetic, Calculation.
Weights	Laws of Gravity.
Forces and Motions	Laws of Dynamics.

TECHNIC EDUCATION, &c.—*continued.*

Mechanical Knowledge.	*Technic Education.*
Strengths	Laws of statics.
Mechanical powers	Theoretical mechanics.
Laws of solids	Kinematics.
Laws of liquids	Hydrostatics and hydrodynamics.
Laws of airs and gases	
Generation of motion	Heat, light, electricity, attraction, and repulsion.
Sources of power	Chemical physics.
Applications of power	Elements of mechanism.
Mechanical inventions	History of machinery.

What Technic Education should we give the Civil Engineer?—The great public works of a civilised country have always demanded and generally received from its Government, earnest solicitude and forethought. In France, the civil engineers are the *élite* of the nation; the most distinguished pupils in the colleges throughout the country are promoted into the central technic institution of France in Paris; and out of this again, a selection is made of the most talented for the "corps de génie maritime;" for the "corps de génie militaire;" and for the "corps de génie civil," or "ponts et chaussées."

By the great public works of a country so much is gained or lost to the public well-being, that the most liberal measures are justified, if they succeed in providing for its service the profoundest knowledge, the most brilliant talent, and the highest skill. In the time of the Romans, Europe was covered with those wonderful roads which have been perpetuated to the present day, and are marvels of conception and execution. The correction of rivers and supply of waters to great cities, the drainage of marshes and the irrigation of plains, have developed the industry and created the wealth of populous countries; and it has depended almost entirely on the wisdom or folly of modern Governments, in the selection of their engineering systems, whether those great engines of commerce, the modern railways, have been given to a country at small cost, on a wise system of development, with gain at once to the capitalist, to the trader, and the Government. Where Governments have been wise, the railways have been well selected, cheaply made, economically and profitably worked. Where they have been reckless, ignorant, unwise, railways have been made at great cost, extravagantly worked, dear to the public, and unprofitable to the capitalist.

When it is considered that the telegraphs which now work the commerce of the world; the great lines of steam-ships which unite its most civilised portions; the railways which everywhere connect the populous centres of empires; the water supply; roads; ports and harbours; the direction, training and permanence of our navigable rivers—are all works involving enormous cost, involving the highest national interests, and requiring consummate knowledge and skill, it is plain that we may judge of the wisdom of a nation by the foresight and forethought it bestows upon the rearing, training, and selection of this *corps d'élite* or *corps de génie*; and it is therefore self-evident that, in a technical university, the pupils of this section must find a prominent place. For England especially, with her wide-spread dominions, it is evident that the youthful Engineer should be prepared to find a sphere of usefulness in any quarter of the globe, and to carry with him a mastery of all the resources of modern science and *skill.*

Technic Education of the Civil Engineer.

Engineering Knowledge.	*Technic Education.*
Laws of water—standing and running	Hydrostatics and hydraulics.
Laws of dead matter	Strength and resistance of materials.
Laws of fixed and moving bodies	Statics and dynamics.
Building of bridges and ways	Theory of structures in stone, timber, and iron.
Surveying, mapping, selection of routes.	Geometry, trigonometry, and surveying.
Erection of buildings	Theory of beauty and ugliness.
Estimates of cost and production of public works.	Prices, wages, and economical valuations.
Steam-ships and machinery	Naval architecture and mechanical engineering.

To a great extent, the civil engineer must have also the same education as the mechanical engineer.

The proposed studies are thus defined:

THE SCHOOL OF MECHANICS.

Pure Science.

Higher Geometry.
„ Algebra.
„ Arithmetic.
„ Statics.

Higher Dynamics.
„ Energetics.
„ Chemistry.
„ Metallurgy.

Practical Applications.

Descriptive Geometry.
Constructive Geometry.
Geometric Movements.
Sources of Materials.
Properties of Materials.
Strength of Materials.
Elements of Mechanics.
Structural Mechanics.
Machinery and Tools.

Engines and Prime Movers.
Economics of Work.
Endurance of Machinery.
Machine Shops and Buildings.
Mechanical Manufactures.
Political Economy.
Workshop Economy.
Principles of Design.

Work.

In the Drawing Office.
In the Collection of Machines.
In the Collection of Machine Materials.
In the Collection of Raw Materials of Manufactures.
In the Collection of Engines, &c.
In Mechanical Experiment.
In the Factory.
Round the Tour of Home Manufactories.
In Foreign Travel.

THE SCHOOL OF CIVIL CONSTRUCTION.

ENGINEERING.

Pure Science.

Higher Geometry.
„ Algebra.
„ Arithmetic.
„ Statics.
„ Dynamics.

Higher Energetics.
„ Hydrology.
„ Chemistry.
„ Geology.
„ Crystallogy.

Practical Applications.

Engines and Prime Movers.
Theory of Vehicles and Locomotive Machines.
Theory of Ships and Steam-boats.
Chemistry of Building Materials.
Geology of Stones and Cements.
Mineralogy and Metallurgy.
Stability of Foundations.
Building Combinations of Materials.
Sources of Materials of Construction.
Theory of Bridges, Roofs, and Tunnels.
Constructive Geometry.
Graphic Geometry and Surveying.
Descriptive Geometry.
Perspective Geometry.
Geometric Movements.
Strengths of Materials.
Elements of Mechanics.
Machines and Tools.
Theory of Rivers.
Theory of Tides and Waves.
Theory of Roads, Railroads, and Canals.
Principles of Architectural Design.
Principles of Metallurgy.
Economics of Construction.
Endurance of Structures, Engines, Machines, and Implements.

Work.

In the Drawing Office.
In the Collection of Engineering Models.
In the Collection of Building Materials.
In the Collection of Machines.
In the Laboratory of Strength of Materials.
In the Chemical Laboratory.
In Engineering Experiment.
In the Factory.
On the Works.
In Foreign Travel.

PROFESSOR LEONE LEVI ON TECHNICAL EDUCATION.

A Parliamentary Paper of 6th December, 1867, publishes—

The Report on Technical, Industrial, and Professional Instruction in Italy and other Countries. By Professor Leone Levi, F.S.A.

This Report, after pointing out the disadvantages likely to arise to this country from a want of proper technical education, recommends, among other measures—

"The establishment of an industrial university, or a superior technical institute for the direction and promotion of technical, industrial, and professional instruction in the United Kingdom."

SUGGESTIONS BY THE ASSOCIATION OF GERMAN ENGINEERS.

In the replies to Lord Stanley's circular, there is given a memorandum drawn up by a Committee of this Association, held at Heidelberg in 1861, as to the organisation of Polytechnic Schools: they say—

In accordance with the national character of the Germans, education for *the higher* technical professions can most advantageously be imparted in

Polytechnic Schools. They should be high schools, and should answer to the highest claims which are made upon those who are to be employed in the technical departments of the service of the State, or in private undertakings, for which a knowledge of mathematics, and the natural sciences and drawing, is necessary.

They prescribe a somewhat advanced standard for admission, and recommend that the schools should afford thorough scientific instruction in—

Architecture.

Engineering (construction, roads, aqueducts, canals, railways, and geodesy).

Construction of machines, and mechanical technology.

Physical and chemical technology; and, under certain circumstances, in

Ship-building, mining, and metallurgy, more especially iron-smelting.

Each principal branch should be divided into an encyclopædical course, giving a survey of the whole subject; and into several separate courses, each, as a rule, extending over six months.

General culture should be encouraged as much as possible.

The plan of studies in the different branches to be recommended to the students should, in preference, include in the first semestre the general sciences; in the second semestre, the technical sciences; but the rule should not be too strictly carried out, as, on the whole, a tendency to divide the Polytechnic School into a number of separate faculties should be avoided.

Where a mechanical-school workshop is organised, the object in doing so ought merely to be to provide the apparatus and models necessary for the instruction given in the school, and the carrying out of experiments required for the solution of technical scientific questions.

In addition to the general certificates, based on the proficiency shown during the course, diplomas of proficiency in any particular branch might be granted after rigorous examination, held before the student leaves the high school, recommending the holder as a person well qualified for his profession. Such examination and diploma ought to secure the privilege of admission to the highest offices in the service of the State for which technical knowledge is required.

A detailed list of the subjects of instruction is given.

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